



1 Fields of application for low-cost robots in households: vacuum cleaning, lawn mowing, window cleaning, transport on tables.

## MOBILE LOW-COST ROBOTS FOR HOME AND GARDEN

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### Starting Point

There is a constantly growing number of low-cost robots on the market for household applications. In contrast to their industrially used counterparts, these robots must meet the following requirements:

- Very low purchase and maintenance costs
- Extremely easy to use, no need for training
- Robust operation in unknown environments
- Small size

So far, applications have been limited to floor cleaning (vacuuming and wet cleaning), lawn-mowing and window cleaning. Additional applications will be available in the medium term.

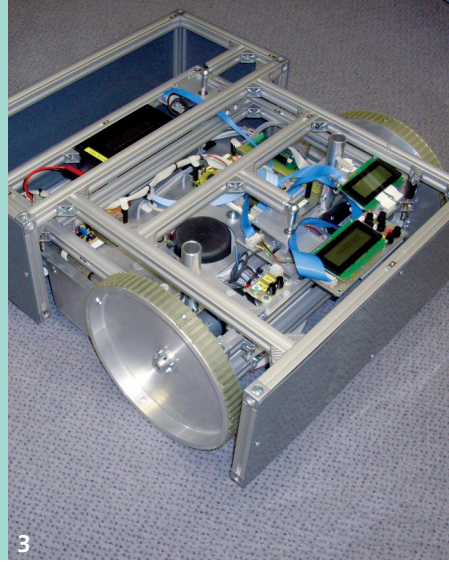
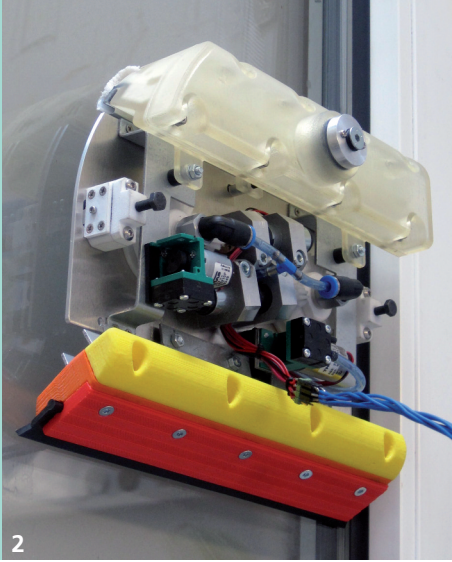
Since the abovementioned applications require an area to be treated in its entirety, these robots – unlike, for example, transport robots – do not move with reference

to target points, but they cover an entire area. At present, most of the navigation methods for generating such movements are still random-based. However, the development trend is towards systematic methods, which, although more complex, permit significantly higher area coverage.

Likewise, movement is being increasingly sensor-controlled, with the result that, for example, the movement of the robot can be adapted automatically to the dirt distribution detected by the sensor.

### Expertise and Infrastructure

For many years Fraunhofer IPA has been engaged in the field of mobile robotics and has during that time collected various expertise both in the construction of complete systems and also in the development and use of entire associated subsystems, including:



- Control architectures (hardware and software)
- Movement kinematics and drive technology
- Coverage and target-point-based navigation methods
- Sensor systems (odometry, inertial sensors, collision prevention, sensors for environment modelling, low-cost image processing etc.)
- Signal processing and sensor data fusion
- Operation concepts and user interfaces
- Control computers (various 8-, 16- and 32-bit microcontrollers and DSPs)
- Software development in C, C++ and other programming languages
- Use of realtime systems such as RT-Linux and VxWorks

In addition to its expertise in the field of mobile robot development, Fraunhofer IPA has an extensive range of systems and tools for the development, analysis, testing and optimization of mobile low-cost robots:

- Over 130 m<sup>2</sup> freely configurable movement areas for the testing of developed navigation systems
- »Living laboratory« for the evaluation of household robots in realistic application environments
- Camera-based tracking system for the recording and analysis of robot paths
- Application-specifically configurable simulation systems for mobile robots including their sensors and movement kinematics
- Diverse development tools for the development of mechanical and electronic systems as well as software

- Several laboratories generously equipped with high-grade measuring and testing equipment
- Workshops for the production of mechanical and electronic prototypes

This equipment allows the systematic and direct development of new processes and controls as well as the fast construction of functional models.

### What we offer

Fraunhofer IPA offers its support in all phases of development – from concept formulation through to prototype development:

- Workshops for concept formulation
- Feasibility studies and market surveys
- Investigation and performance analysis of already existing products
- Design of mobile low-cost robots and their subsystems, taking account of narrowly defined parameters and constraints with regard to production costs
- Development of new sensor concepts considering space requirements and costs
- Development and construction of functional models, both mechanical and electrical systems as well as electronics and software
- Integration of existing components, e. g. cleaning systems developed by a customer
- Extended-time tests with automatic data recording and subsequent evaluation
- Support with the development of prototypes and series-manufactured products

### References

In recent years, Fraunhofer IPA has realized a variety of low-cost robots whose development was focused from the outset on their rugged construction from cost-effective, space- and energy-saving components:

- Development of various climbing robots as the basis for autonomous window-cleaning systems
- Development of several testing platforms for the study of novel navigation strategies
- Development of a novel lawn-mowing robot including control software
- Development of Tabl-O-bot, a robot transporting objects on tables
- Design and realization of a systematically functioning area-coverage navigation method for indoor robots including the necessary control and sensor components
- Development of a mobile communication robot for emergencies

2 *Window cleaning robot "Quirl".*

3 *Prototype of a new lawn mowing robot.*

4 *Mobile emergency assistant "MoBiNa".*