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Efficient Automated UHF-RFID Inventory and Localization of Goods & Books by Autonomous Robots
About MetraLabs GmbH, Germany
Development and manufacturing of autonomous mobile Robots and engineering services for retail, industry, health care and research institutions

>10 years of experience
- Founded in 2001
- Experts in autonomous mobile robot technologies and robot interaction
- Based in Ilmenau, Germany

>70,000 km autonomous driving
- Completely autonomous driving
- Approved for safe, unsupervised use in public environments (CE/TÜV)
- No manual interaction required

ca. 250 robots deployed worldwide
- MetraLabs gathered global experience in projects all around the world
- Our robots are deployed in: EU, USA, Canada, Russia, China, Brazil, UAE etc.

High service quality
- 20 employees, 14 permanent employees
- Highly educated and experienced colleagues
- Personal contact guaranteed
Pioneering product milestones:

Worldwide...

2007  First interactive shopping robot
2009  First clean room monitoring robot
2010  State Research Prize
2010  First service robot in a fast food restaurant
2014  50 robots in a shopping mall in Shanghai
2015  First RFID inventory robot in continuous live operation worldwide
Typical service robot applications

General applications:
- Guiding (provide information)
- Monitoring (gather and report information)
- Transportation (fetch or deliver items)
- Entertainment (play games, formation dance)

Specific applications:
- Giving customers overview of products and guidance to shelves
- Surveying and reporting pollution levels in cleanrooms
- Support pickers in logistics
- Dancing to music in a synchronized group performance

... and last but not least:
- Performing autonomous inventory using UHF -
Mobile Service Guides (examples)
SCITOS platform family

- Versatile, modular and robust mobile robot base
- Safety: Technology certified for safe use in public environments (CE/ TÜV)
- Various sizes and shapes available or custom made
- Extensible with additional sensors and manipulators
- Differential drive, additional castor wheels for stability
- Velocity usually: up to 1.4 m/s
- Payload usually: 50 .. 250 kg
- Operation time: 12 .. 18 hrs.
- Charging time: 3 .. 6 hrs.
- Autonomous charging at charging station
- Industrial embedded PC with latest Intel iCore processors
- OS Linux (Cent-OS etc.)
- Interfaces: CANOpen, Ethernet, Wi-Fi, USB, Bluetooth, ZigBee, GSM/ UMTS/ LTE etc.
**Navigation Software CogniDrive®**

- Laser- and vision-based 3D obstacle avoidance methods considering robot’s geometry
- Fast mapping and teaching even of large operational environments and production halls
- Robust autonomous driving in narrow, crowded and changing environments with reliable obstacle avoidance capabilities
- Coordination of several collaborating robots (swarm behavior)
Application: Stock-taking (use case is fashion store)

Current processes in retail and logistics:

- Inventory using handheld RFID readers requires dedicated staff
- Typically low read rates (<5000 tags/h) and accuracy (<98 %)
- Infrequent inventory due to high staff time expenditure and cost

→ **Robots can improve costs, frequency and quality of inventory**

Benefits for retailers and for libraries:

- Early recognition and prevention of out-of-stock situations
- Reduces employee workload and shifts focus to customer service
- **Accurate localization of goods** (misplaced books or merchandize...)

Stock-taking: RFID inventory robot

TORY – Efficient automated inventory

- Compact and durable platform with high capacity battery
- Intelligent multi sensor systems for autonomous navigation
- Easy infrastructure integration due to standardized connectivity
- Fast return on investment, easy installation and staff training

Operational parameters:

- Robust differential drive system for speeds of up to 1.0 m/s
- **18 h** operation time with ca. **4h** recharge time
- Custom reader for high read rates (up to **250 tags/s**)
- Specialized antenna design for high sensitivity (range up to **8 m**)
- Virtually unlimited memory for tracking read tags (>**1 million tags**)
- Standardized interconnectivity (WiFi, USB, FTP, SMTP, SQL, ...)

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Stock-taking: Results of field trials

User trials at several fashion retails:
- Conducted user trials with half a dozen retailers
- Evaluate viability of robots as replacement for handheld inventory
- Benchmark of transponder capture accuracy: ≥ 98.5 %

Trial environments:

<table>
<thead>
<tr>
<th>Store</th>
<th>Shelf types</th>
<th>Size</th>
<th>Time</th>
<th>Read rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store A</td>
<td>Tall metal shelves</td>
<td>275 m²</td>
<td>1h 45m</td>
<td>98.7% → 99.7% (incr.)</td>
</tr>
<tr>
<td>Store B</td>
<td>Mostly low racks</td>
<td>2500 m²</td>
<td>~2h 30m</td>
<td>99.0% (overall)</td>
</tr>
<tr>
<td>Store C</td>
<td>Tall metal shelves</td>
<td>4000 m²</td>
<td>~6h 15m</td>
<td>“good” (~99%)</td>
</tr>
<tr>
<td>Store D</td>
<td>Evenly mixed</td>
<td>2000 m²</td>
<td>~3h</td>
<td>“more than required”</td>
</tr>
</tbody>
</table>

(data as disclosed by retailers)
Insight #1: Excellent read performance
- Single run read accuracy matches or exceeds handheld accuracy
- Several times higher read rate (20’000 to >60’000 tags/h)
- Provides accurate localization (up to 1 m) of individual products
- Aptly deals with tall shelves and densely packed merchandise
- Incremental integration over several runs yields precise inventory

Insight #2: Practicable and easy operational integration
- Quick and easy set-up procedure and fully unattended operation
- Requirements for daily operation set by retailers were fully met

Insight #3: Suitable fully autonomous navigation
- Fast enough to perform a full nightly inventory even in large stores
- Changes to environment (moved racks, ...) can be dealt with
TORY’s view at two sales floors of a retail shop

1st Floor (1500 m², ca. 23k UHF-RFID-tagged items)

2nd Floor (1100 m², ca. 16k UHF-RFID-tagged items)
But how does TORY perform in a library?

Max Planck Institute Luxembourg Library
- Books equipped with UHF RFID transponders
- First test of TORY in a library (26th Oct. 2016)
- Ca. 35’000 books to capture by UHF-RFID
- Total scan area incl. hallway ca. 600 m²
Impressions of TORY at MPI-Luxembourg Library
Promising results as inventory solution for libraries:

**Evaluation in Max Planck Institute Luxembourg Library**

- **Results:** 34’815 books read (RFID-tagged items) of ca. 35’000 books → **more than 99 % captured**
- **Duration time:** ca. 1 h for robot taking inventory
- **Path length:** ca. 900 m of driving for taking inventory
- **Estimation of position of tags below in green and blue dots** (without any specific modelling of RF-tags and optimisation)

*green* is high on read signal strength → more precise position estimate; *blue* is less confident
MetraLabs’ SCITOS robot technology

- Facilitates Industry 4.0 advantages and lean processing principles in industry, retail and libraries
- Complete automation of daily operation, from task execution to battery recharging
- Reduced operational costs and decreased manual labor overhead
- Approved for safe, unsupervised use in public environments (CE/TÜV)
Ready to go: TORY and his robot family

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