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Maru and Toru:

Item-specific logistics solutions based on ROS

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In today’s warehouses

it’s always either man-to-goods or goods-to-man,
but the human is still the central factor in all intralogistics processes.

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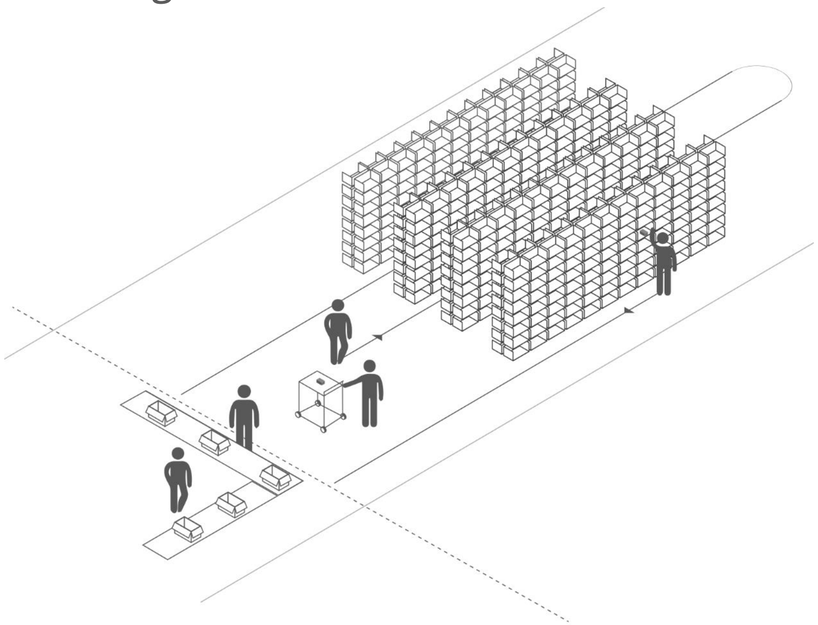
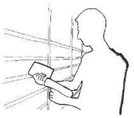
Man to goods

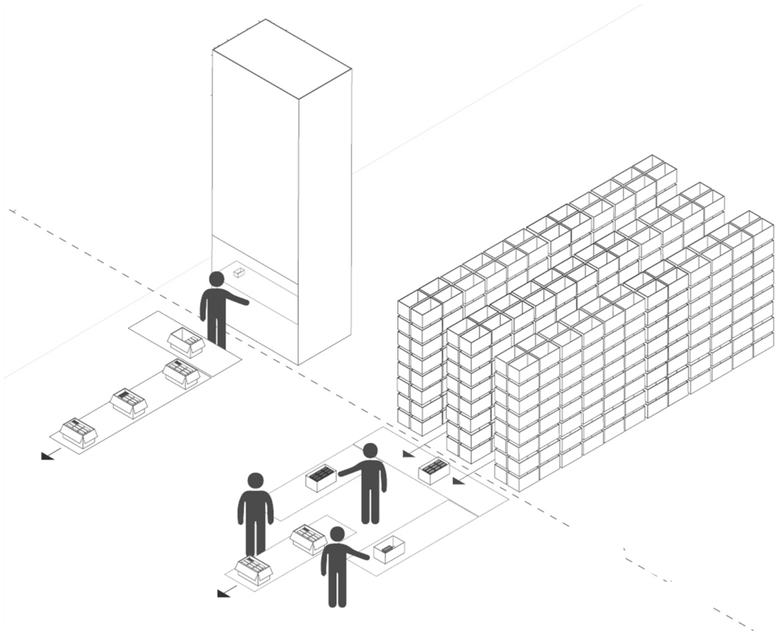


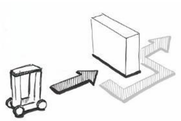


Dependence on staff

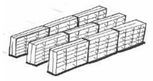
High salary and process costs

Goods to man



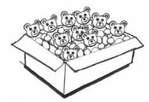


Missing flexibility



Missing scalability

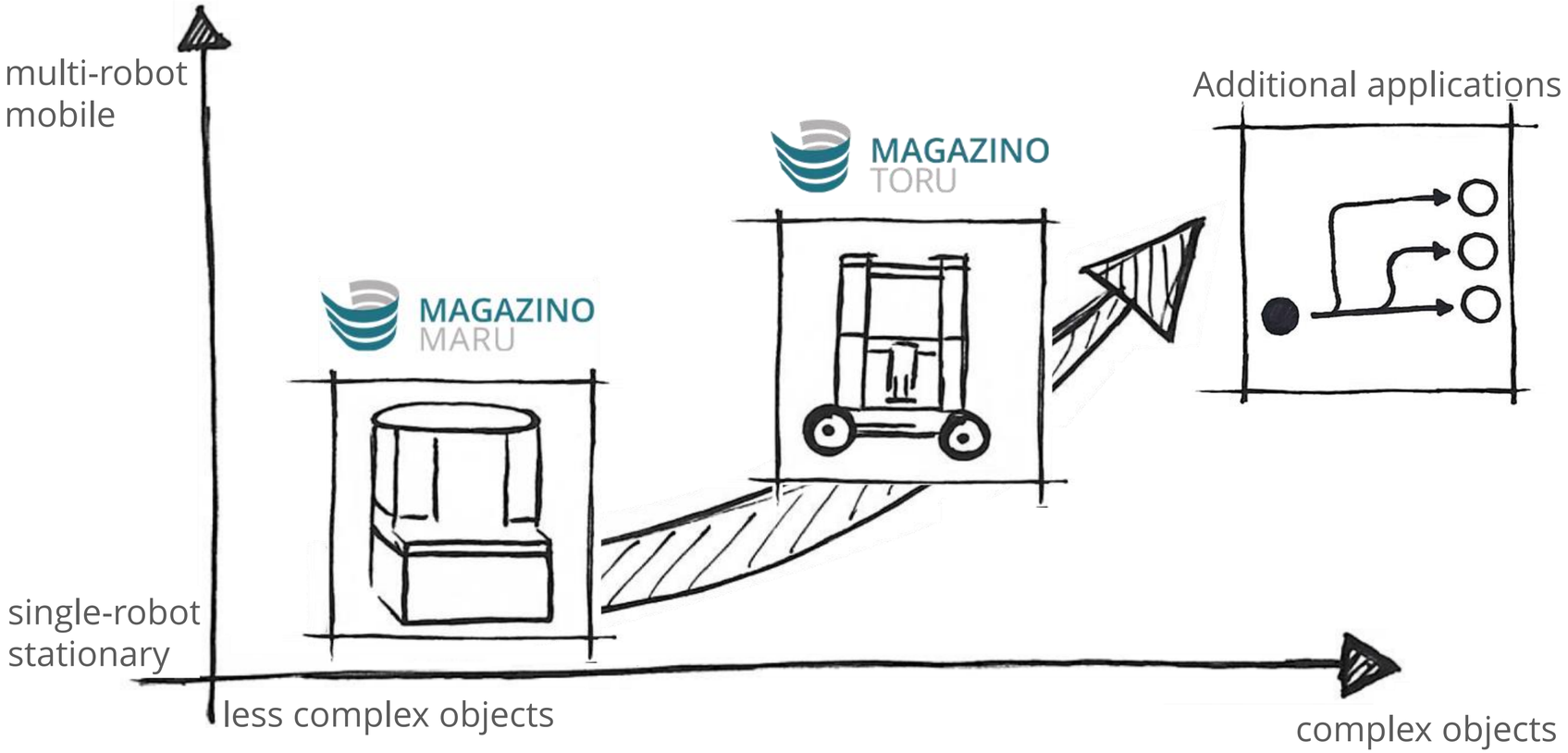
High initial investment



No individual object grasping

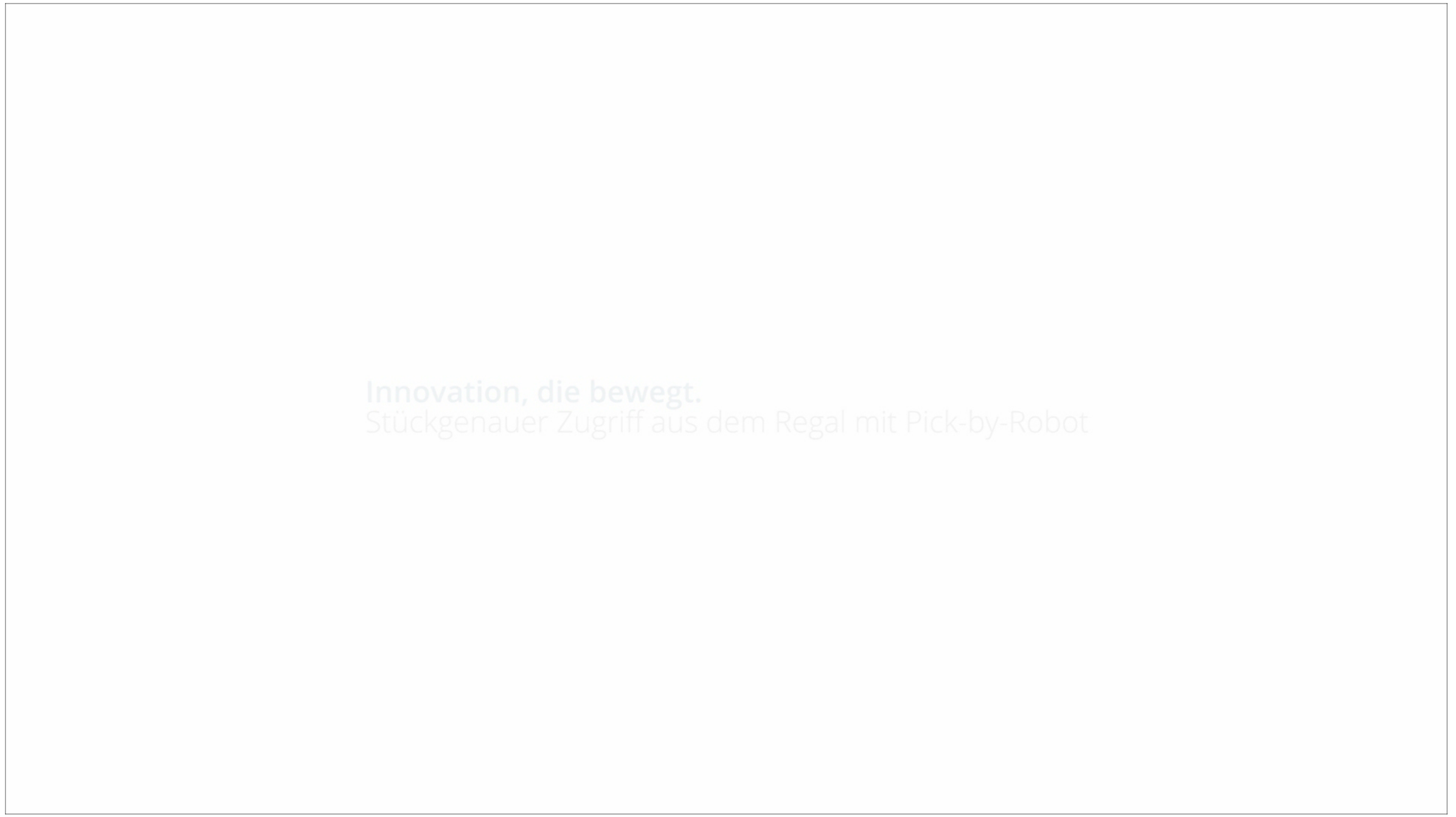
Our vision

is to scale from less complex objects and stationary operation towards mobility and applications beyond logistics.



Introducing TORU,

an „automated contract worker“, a robot as flexible as the human
that collaborates with the human and picks items directly from the shelf.



Item-specific handling in logistics requires new robotics concepts

to deal with the increased uncertainty and the diversity of objects to be picked.

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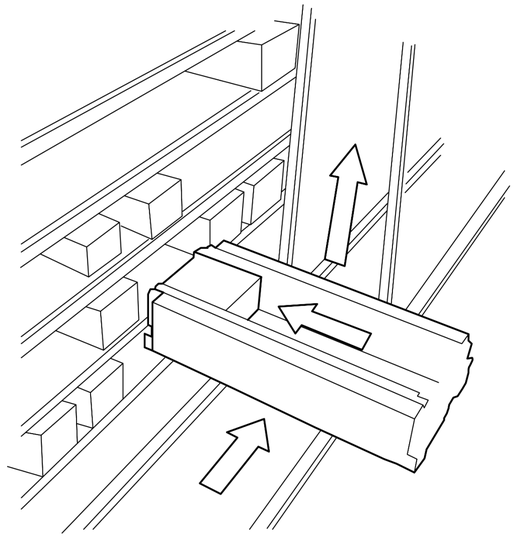

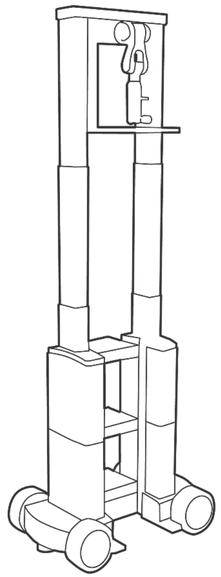

Current warehouse automation

- Rack feeder on rails, standardized carriers, recurring tasks
- Highly structured, static environment with minimized uncertainty
- Reliability achieved by carefully engineered components
- Either 100% or no automation

→ **Highly deterministic environment**

Perception-controlled logistics robots

- Robots **navigating freely** between shelves designed for humans, picking a **wide range of objects**
- Dynamic environments with **high uncertainty**, flexible adaptation to novel objects, tasks and warehouses
- Scalability and **reliability through redundant teams** of robots
- Human-machine collaboration allowing **incremental automation**

→ **Highly autonomously acting robots**

New programming approaches enabled by ROS

are needed because classical PLC programming does not scale well to perception- and cloud-based robotics tasks.

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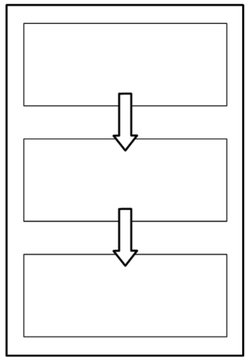
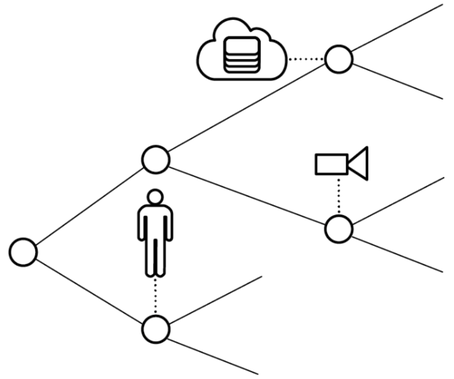




Current warehouse automation

- Environment is completely known at programming time, so movements can be predefined
- Low uncertainty requires only few sensors at well-known positions
- Programs remain the same over the lifetime of a system

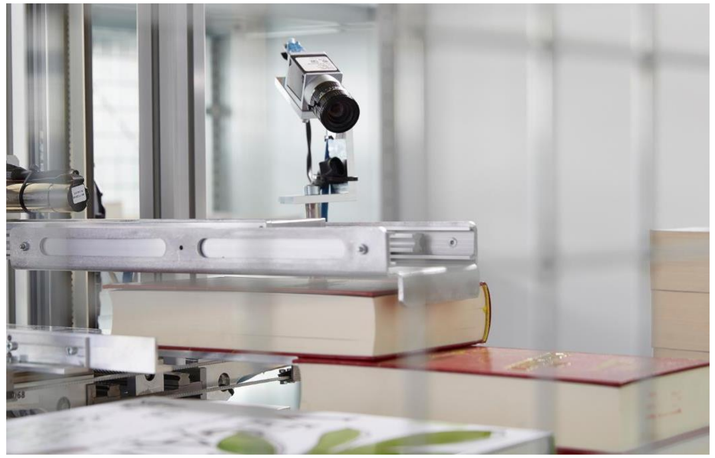
Perception-controlled logistics robots

- Environment is dynamic, so robots have **to plan motions at runtime** after perceiving objects and **react to events** and errors
- Seamless integration of object perception for **dealing with uncertainty**
- **Fast adaptation** of control programs through task editor, database connections and cloud infrastructure

→ Offline programming of mostly sequential tasks

→ Reactive and perception-guided control programs

Where are we?



What have we learned?

And how does ROS help us achieve our goals?

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1. Perception has to be an integral part of the system, not a one-time task
2. Databases and persistent information storage are crucial components
3. Only few parts of the system have to be real-time
4. Developing software in simulation parallel to the hardware allows fast iterations
5. The ROS community, common practices and (still) ease of use are important

Perception needs to be an integral part of the control system

for object recognition and run-time adaptation and correction of robot movements.

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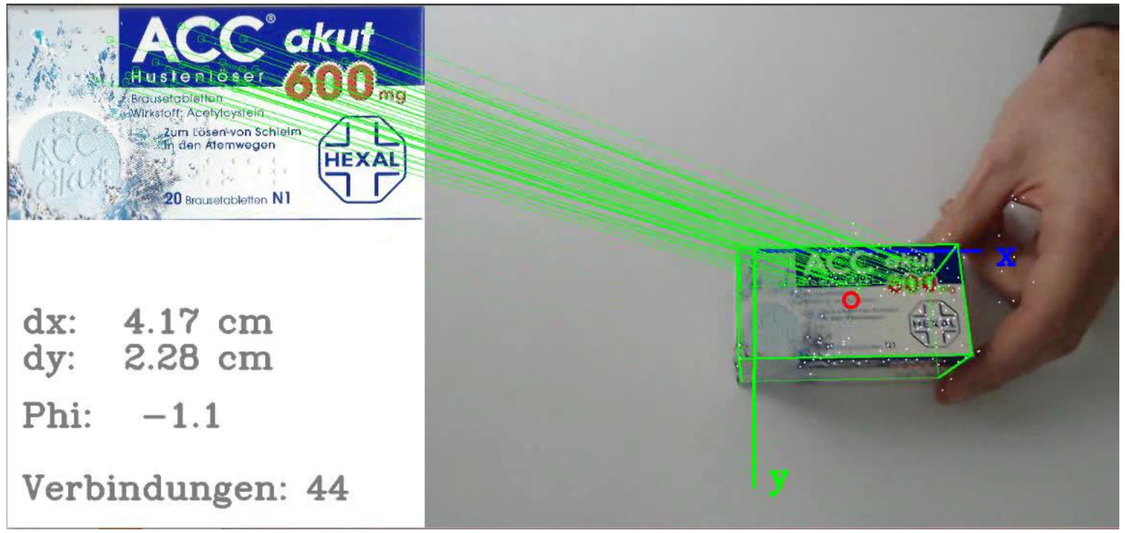

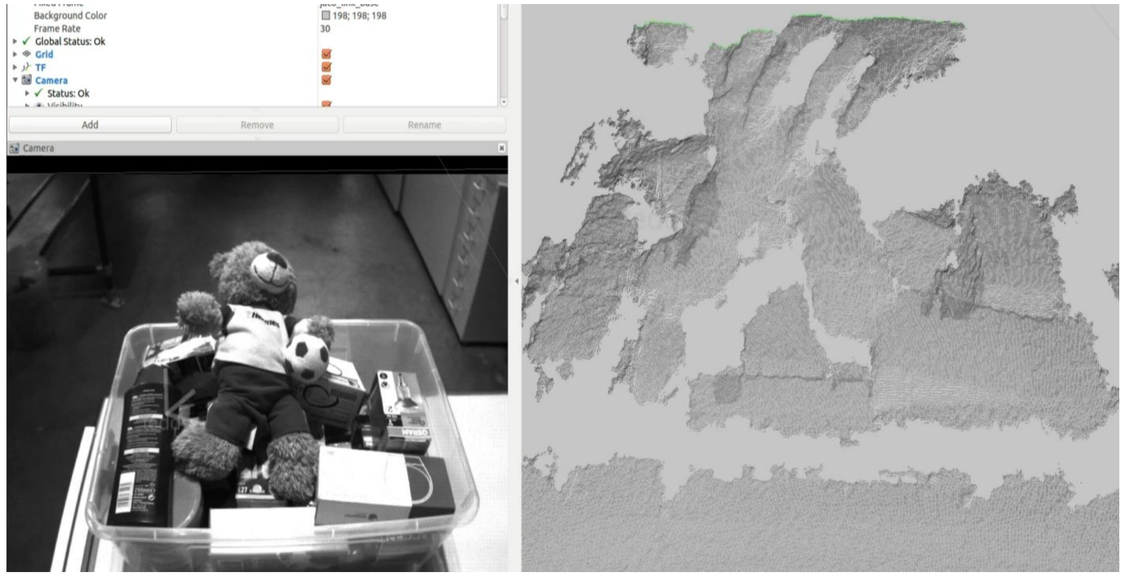

Databases and persistent information storage are crucial

for managing environment information and for making sure that important data on the execution state is not lost.

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Persistent storage of

- Environment state
- Robot state (e.g. object picked?)
- Error states
- Parameters
- Log data and statistical information

Not all parts of the control system have to be real-time,

which allows for much faster and more convenient development of higher-level algorithms.

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- Real time controllers directly on the plug-and-drive motors
- CANopen interface to ROS
- All medium- and high-level control in ROS in a non-realtime environment
- Facilitated and sped-up development

Developing SW and HW in parallel

using simulation and hardware abstraction allows to speed up iterative development of new robot systems.

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Agile SW/HW development:

- Rough design in CAD program
- Export to simulation model
- Production using 3D printers
- Test the first prototype only few days after the idea came up
- Identify shortcomings, improve design, continue with next iteration

ROS is the environment we feel comfortable in

(as well as many recent robotics graduates)

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- Common workflow for installing, building, launching, debugging packages
- Multi-language build system
- Flexible development on different computers, languages, OS, architectures
- (Still) easy to use
- Helps with hiring and onboarding new employees that know ROS

Some of our use cases are not yet covered by ROS

and therefore require custom solutions for now

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- Varying quality of software components
  - ROS Industrial: ratings and metrics for assessing code quality
  - Currently, we mostly use well-tested core components and our own packages
- High-level task coordination libraries
- Integration of the runtime communication with persistent information storage
- Support for (remote) debugging, logging, performance analysis, statistics
- Multi- and many-robot systems: task allocation, navigation planning etc.
  - How much do the robots need to know about each other? How much communication is actually needed?

Conclusions

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- New applications such as item-specific logistics require new programming approaches not provided by classical automation tools
- ROS is well suited to these problems and supports rapid development of robot products
- The community, common approaches and standard workflows are helpful for hiring and onboarding developers in a startup company
- We hope the ease of use and vibrant community will remain intact
- Incremental evolution and migration paths would help us to adapt to future versions of ROS and stay connected to the community

Welcome in our office

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