MORE THAN ROS

All the attention that ROS (Robot Operating System) is getting nowadays is completely justified. After all, this meta-operating system is responsible for sparking a new way of thinking on how to compose robot applications with a lot of capability for our homes and public spaces using re-usable software. Before that, industrial robot manufacturers had kept us believing that robots were expensive, dangerous and not easy to use. All this being said, there are more options available than this open-source software framework called ROS. The world needs modular robot software and robot hardware, including safety, to build reliable and secure applications.

HENK KIELA

Robot times

With robotisation now really raking off, we are definitely living in interesting times. After the recent technological innovations of computers, mobile phones, internet and smartphones, robots will now enter our lives in various forms. “We’re not seeing the robots yet, but we certainly could use a few” is one of the reactions many people have – a striking response given that only a few years ago robots were seen as a threat to our global workforce. But people’s attitude is definitely changing to working with the three Ds – dirty, dull and difficult.
Although we may not see a lot of robots in daily life outside factory walls, closer inspection reveals that robot technology and artificial intelligence (AI) can be found in common products. Robot vacuum cleaners for example and robotised lawn mowers are still rare, but these early examples of a new generation of robots are changing the way vacuum cleaning and lawn mowing are fundamentally done.

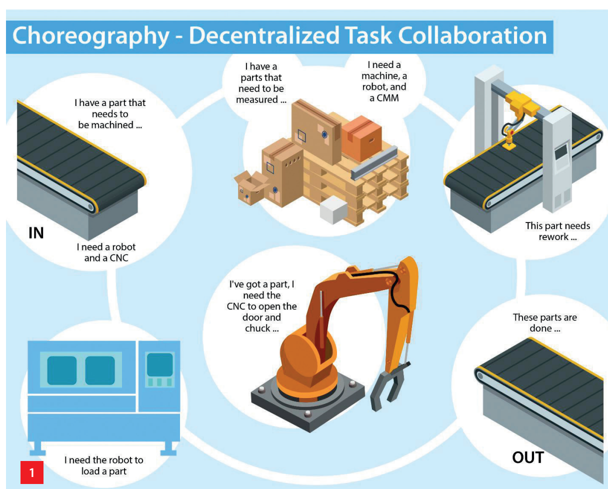
While the principles we now use in technology and AI were determined 20 years ago or more, we still aren’t seeing many robots around. The explanation is simple. Robots first need to become a lot cheaper and a whole lot easier to use. And more importantly, these robots need to be able to cope with the unstructured environment we live in and do something useful in a safe and pleasant way. As humans, we’ve only just started to understand the social patterns of how we interact with each other. AI will help robots in the near future to ‘understand’ humans in the environment and interact with them in a way that humans understand.

Interestingly, industry is driving new applications of humans and collaborative robots, i.e. cobots, working together. Development in Smart Industry (in the Netherlands) and Industrie 4.0 (in Germany) underline the importance of robotisation, cobots and connected distributed production cells to improve flexibility and reduce the offshoring of work to low-wage countries.

This vision of Smart Industry has also been adopted by the ROS community [1] and the ROS Industrial [2] community. The ROS open-source initiative took off at Stanford University in California, USA, around 2008 in an effort to speed up robot developments by connecting all relevant open-source software in one framework. The ROS community shares the idea of flexible production with the help of robots (figure 1) and the way equipment takes the lead in inviting peer robots to collaborate rather than that the whole system being driven top-down.

ROS evaluation

The worldwide ROS community brings together all relevant knowledge and a variety of robot-relevant open-source software on a ‘standardised’ platform, or middleware, running on Linux. As the quality and reliability of this software was not as good as everyone had hoped, the ROS Industrial community started working on a more reliable ROS version.



The ROS community shares the idea of flexible production with the help of robots that are able to ‘understand’ what the other team members need and/or are doing. [3]

AUTHOR’S NOTE

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The principles of ROS and ROS Industrial proved that modular software indeed helps to speed up the development of robot applications. But the system was not sufficiently reliable, did not offer any safety and still required a lot of expertise to 'compose' a robot system. The ROS 2.0 project was started recently, incorporating the new requirement for mission-critical functionality and indeed safety.

Whatever you think of ROS, it has changed the thinking about robots regarding such things as the affordability of complex technology, the flexibility in recomposing robot functions and how to provide a way for worldwide collaboration in robot developments and research. The amount of open-source software compatible with ROS is dazzling and still growing fast.

However, our company Probotics decided not to continue with ROS for a number of reasons. As a manufacturer of self-driving robot systems, we have to deal with many more aspects than ROS covers. To sell safe and reliable self-driving vehicles (SDVs) for an industrial logistic application that is easy to integrate on the shop floor and easy for non-technical people with a non-academic background at our customers to maintain, you need to provide reliable and very-easy-to-use robot systems.

SDVs are the next generation of automatic guided vehicles (AGVs), except these SDVs navigate on environmental features and not on fixed lines and floor features. As such, SDVs are much more flexible than classic AGVs. They provide mobile logistic solutions that are safe, low-cost, easy to reconfigure and easy to integrate, even without the need for ROS.

Because the focus is on ROS, many people may have forgotten that there are a number of alternatives around to build mobile robot systems with affordable industrial components. Companies such as the Swiss company BlueBotics and the Finnish company Navitec developed their SDV navigation systems a few years ago and have sold over 1,000 systems worldwide to mobile robot manufacturers and integrators. These systems provide navigation, localisation and fleet/traffic management. Their systems are open, very reliable and simple to integrate and to maintain.

They have a few aspects in common with ROS, which the ROS community is not addressing very well. As already mentioned, safety in ROS and ROS Industrial is almost invisible in the software and barely discussed in the community – it sometimes doesn't even seem to be an ambition. What's more, the reliability of open-source ROS-driven robots is a serious consideration.

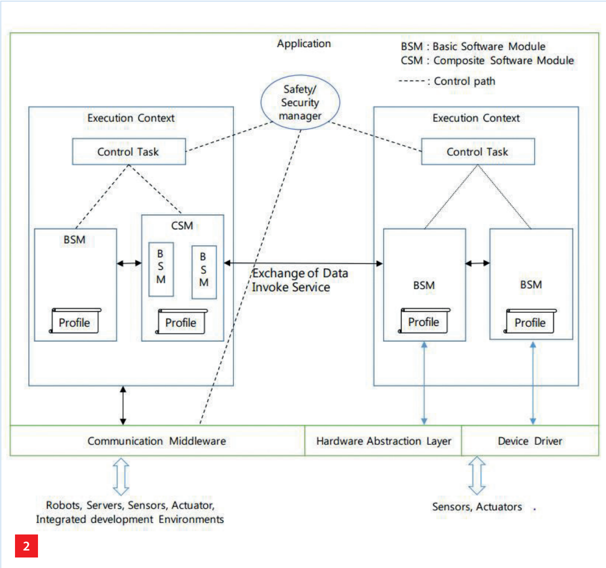
The main function of a self-driving robot is navigation. This can be defined as the combination of the three fundamental competences:
1. Self-localisation
2. Path planning
3. Map-building and map interpretation

To build a safe and reliable SDV, more is needed. Table 1 presents a comparison of some aspects from industrial navigation systems and ROS, using the operating systems of BlueBotics and Navitec as examples, as these are familiar to us. But there are more suppliers of similar systems on the market, with similar capabilities.

Table 1
Comparison of aspects relevant to industrial navigation.

	BlueBotics	Navitec Systems	ROS
Re-configurability of SDV for new tasks	Very simple through CAD-based tools.	Very simple through CAD-based tools.	Reprogramming, reconfiguring launch files, validation of new configuration needed.
Safety	Safety-related features and functions, integrity check and signals.	Safety-related features and functions, integrity check and signals.	No safety, you have to build it yourself; no aspects regarding performance or safety present in any module today.
Security	Vulnerable, but documented.	Vulnerable, but documented.	Very open system, easy to intrude and disturb.
Navigation	Very reliable, easy to reconfigure; little effort required to make changes in routes and maps.	Very reliable, easy to reconfigure; little effort required to make changes in routes and maps.	Very dependent on many settings and configuration files; poor and complex documentation.
Hardware reconfiguration	Good plug & play support for major (safe) hardware suppliers.	Good plug & play support for major (safe) hardware suppliers.	A lot is available, but quality and ease of reconfiguration is not as good.
Integration with production environment	Good, many options on board and available remotely via network.	Good, many options on board and available remotely via network.	Has to be developed, few or nothing available.
Fleet/traffic management	Standard, easy integration with warehouse management system (WMS).	Standard, easy integration with WMS.	Possible, most of it has to be developed.
Cost	Fair, all-in-one package, good support.	Fair, all-in-one package, good support.	Open source is 'free'; the effort to make it a reliable and safe system is unpredictable.
Fit-for-future challenges	New challenges need to be developed.	New challenges need to be developed.	Latest functionality probably available; validation needs attention.
Community supported	None.	None.	Growing worldwide community.
Fit for many more robot applications	Impossible.	Impossible.	Very good ability.

Key: Good | Fair | Weak



Software modularity as described in the ISO 22166 standard.

Based on our observations, it can be concluded that ROS definitely has its qualities, certainly when looking to the future. But there are cheaper, safer and much more reliable systems available on the market for industrial SDV applications .

Standardisation

While classic industrial robot manufacturers kept telling us years ago that robot control is complicated and that software can't be made modular, ROS has demonstrated the opposite. Modularity in software is possible and offers great advantages in dealing with complex robot systems. This is also reflected in the ISO initiative. Modularity for robot systems has gained a global momentum thanks to the efforts of the Technical ISO Committee TC299, which, in 2014, resulted in a new project to develop a standard for modular robot functionality: ISO/CD 22166-1.2, "Robotics - Modularity for service robots - Part 1: General requirements" [4].

This new ISO standard incorporates hardware and software modules and includes guidelines for the design of safe and secure robot modules. While all of the software aspects presented in this standard are applicable to ROS modules, the ROS community has surprisingly shown little interest in participating in this effort.

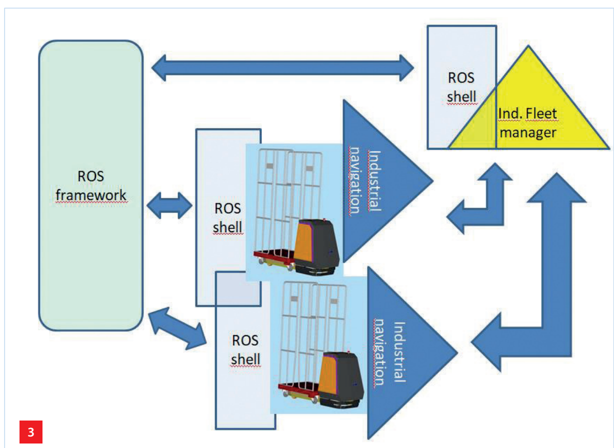
The principles presented in this standard help to incorporate safety and security in modules and in module architectures in an industrial manner. If these principles are followed at an early stage of module design, either in hardware or software, the cost of achieving a certain safety performance is low and the result for system integrators will be great. Those integrators who adopt the guidelines at an early stage of development have to spend a lot less time on integrating certified modules into a system, compared to ROS modules, to build a reliable safe and secure robot application. Figure 2 illustrates this standard in terms of software modularity.

Future perspective

ROS and manufacturers of relevant industrial navigation modules seem to be working in different worlds, while there could be major benefits if these two worlds were connected. There are at least two ways to promote more affordable, robust and flexible robot solutions in our world for both ROS and industrial suppliers:

1. Existing manufacturers of robot systems and robot modules cannot ignore the ROS community. They have to provide interfaces to ROS and become part of the ROS (Industrial) community rather than seeing ROS as a competitor. They have been working according to industry (safety) standards for a long time, their products are reliable and simple to configure, but they must now consider providing standardised interfaces to ROS to open up a new market. The ROS community needs this kind of reliable and safe functionality, and will embrace products with an ROS interface.

2. The growing ROS community is driven by science, not by industry, which is good. But it does not pay enough attention to reliability, safety, security, maintenance and support. These aspects have to be addressed in the architecture and implementation of ROS modules. ROS is not interested enough in hardware and integration aspects. In 2018, ROS 2.0 defined some ambitious goals regarding these aspects. But ROS is at least 10 years behind on these aspects compared to the industry that incorporated these aspects in their robot products a long time ago. Opinion leaders in the ROS community see less



Example of a hybrid system of industrial-grade professional components controlling a fleet of vehicles connected to an industrial fleet/traffic manager and ROS functionality.

value in complying with standards for safety and security. Some of the companies that brought robot products to the market based on ROS had to spend quite some time on making their product fit for industry.

Manufacturers

Manufacturers have to reconsider their position with respect to the expanding ROS community. They can no longer ignore the existence and importance of this community. Building a new relationship with the ROS community will open up new markets for the industrial-grade products they offer.

Universal Robotics and others manufacturers have shown the commercial benefit of embracing ROS and their products are greatly appreciated by the ROS community because of their reliability and price/performance ratio. Figure 3 shows an example of a hybrid industrial-grade/ROS system.

Building an ROS interface is not difficult for a manufacturer; it is merely a choice based on their vision of the future. My message to manufacturers of industrial robot modules is: "Don't be afraid to join the ROS community." There is no risk of losing market to a competitor. First of all, ROS is not a company, but a community with its own, non-commercial, behaviour and with a huge potential to embrace ROS-compatible products enthusiastically.

There is a need for good quality functionality. And once an industrial module is open to ROS, all other developments in ROS can become part of joint products. And last but not least, a supporting ISO standard is on its way to help structuring the quality and integration of robot modules.

ROS community

Rather than broadening the scope of ROS towards new applications like 3D printing, community efforts should also at least focus on quality of service for existing ROS functionality, and simplification of use of ROS and reconfiguration. They should also incorporate safety and reliability in their concept. This has now been defined in ROS 2.0. But the target timelines for these ambitions and specifications are still unclear.

In our view, there is a strong parallel between ROS modules and the development of apps for smartphones. Initially, app stores were open arenas where everyone could post apps. This resulted in unreliable applications that even jeopardised smartphone integrity and security. Manufacturers responded by imposing guidelines and quality criteria on new apps.

A store of ROS-certified modules could provide a similar function to the user community. The certification should provide minimum qualifications for the performance, safety, security and maintainability of a module. Such a scheme could be adopted for ROS 2.0 in the future, but this should also be done right away for ROS Industrial. This would help enormously to attract industrial suppliers of robot modules and components to become part of the community and help system integrators to introduce complex robot solutions with less effort into our society. In the end, everyone would benefit.

REFERENCES

[1] *www.ros.org*
[2] *www.rosindustrial.org*
[3] *www.mtconnect.org*
[4] *www.iso.org/standard/72715.html*