KONICA MINOLTA

Distributed Robotics: Building an environment for digital cooperation

Artificial Intelligence series

Giving Shape to Ideas

From programmable machines to intelligent agents

Robots, from the Czech word *robota,* meaning 'forced labour', are classically defined as programmable machines that can execute actions and tasks autonomously. Industrial robots that have been used since the late 1930s[1] surely fall within this category. But what about autonomous drones? Or companion and social robots? Today, robots are increasingly seen as *intelligent agents* that can perform actions that have effects on the physical world. It is the *artificial intelligence* within and around robots, rather than the pure automation, that is creating a paradigm shift within robotics. But what is actually needed to make robots more intelligent?

Industrial robots, medical robots, social and companion robots and drones are all experiencing a transformation. A key aspect of this transformation is the increasing digitisation of ourselves and the environment that we live in, and the possibility of robotic systems that can interface with this world. It is the engagement of robotic systems with this new formalised digital environment, augmented by artificial intelligence (AI), which will enable robots to be more than just isolated and pre-programmed autonomous systems. In the future, with the inclusion of robotic systems within this digitised world and empowerment through AI, robots that previously could only execute simple, repetitive functions will be able to be more adaptable and perform increasingly complex and diverse tasks. This will open the possibility of robots to seamlessly work beside humans across multiple domains.

The future of robots requires a software architecture that will enable the interfacing of robotic systems and sensor networks, together with digital platforms. This architecture will not only orchestrate complex autonomous workflows, but it will also enable robots to engage in a coherent digital environment, together with other digital and physical entities, and within physical environments.

> "The intelligence emerging from the network of AI agents and Cognitive Hub will support humans as well as robots and enable them to better collaborate within digital and physical spaces."

At Konica Minolta, we are addressing this challenge by developing Cognitive Hub, a system composed of multiple platforms that connects different kinds of robots through a layer that we call the *distributed robotic platform*. This distributed robotic platform will have an impact across all verticals. From the industrial and medical settings, to the household and office environments, the combination and orchestration of robotic systems with sensor technologies, computer vision and machine learning, and their interface to other digital entities will revolutionise how robots interact with spaces and with people.

[1] "An Automatic Block-Setting Crane". Meccano Magazine. Liverpool UK: Meccano. 23 (3): 172. March 1938.

Intelligent robots: a first glimpse at multiple scenarios

The Factory of the Future. The 4th industrial revolution is setting the stage for a dynamic production environment which is distributed and programmable through software, and in which robotic and autonomous systems will be governed by platforms that will connect robots and sensors to data analytics and machine learning services. Cognitive Hub will especially target the manufacturing industry, connecting industrial robotic platforms to the distributed robotic platform. This will enable industrial robots to perform more complex and diverse assembly operations in manufacturing processes that will ultimately lead to a more agile manufacturing system.

Medical robotic platforms. Robotic technologies were first introduced in healthcare over two decades ago with the first robotic surgery devices[5]. Today robotic systems are not only connected to the operating theatre, but in recent years the advent of sensor-fusion technologies are also having a strong impact in the diagnostic medical settings, connecting traditional medical imaging together with robotic technologies. Across both interventional and diagnostic medical robotics there is an increasing need for the contextual awareness of robotic systems and for enhanced collaborative robotics. Leveraging on Konica Minolta's presence in medical imaging and our research and development activities in digital healthcare[6] and distributed robotics we are working with leading academic institutions to extend our distributed robotic platform to the medical domain.

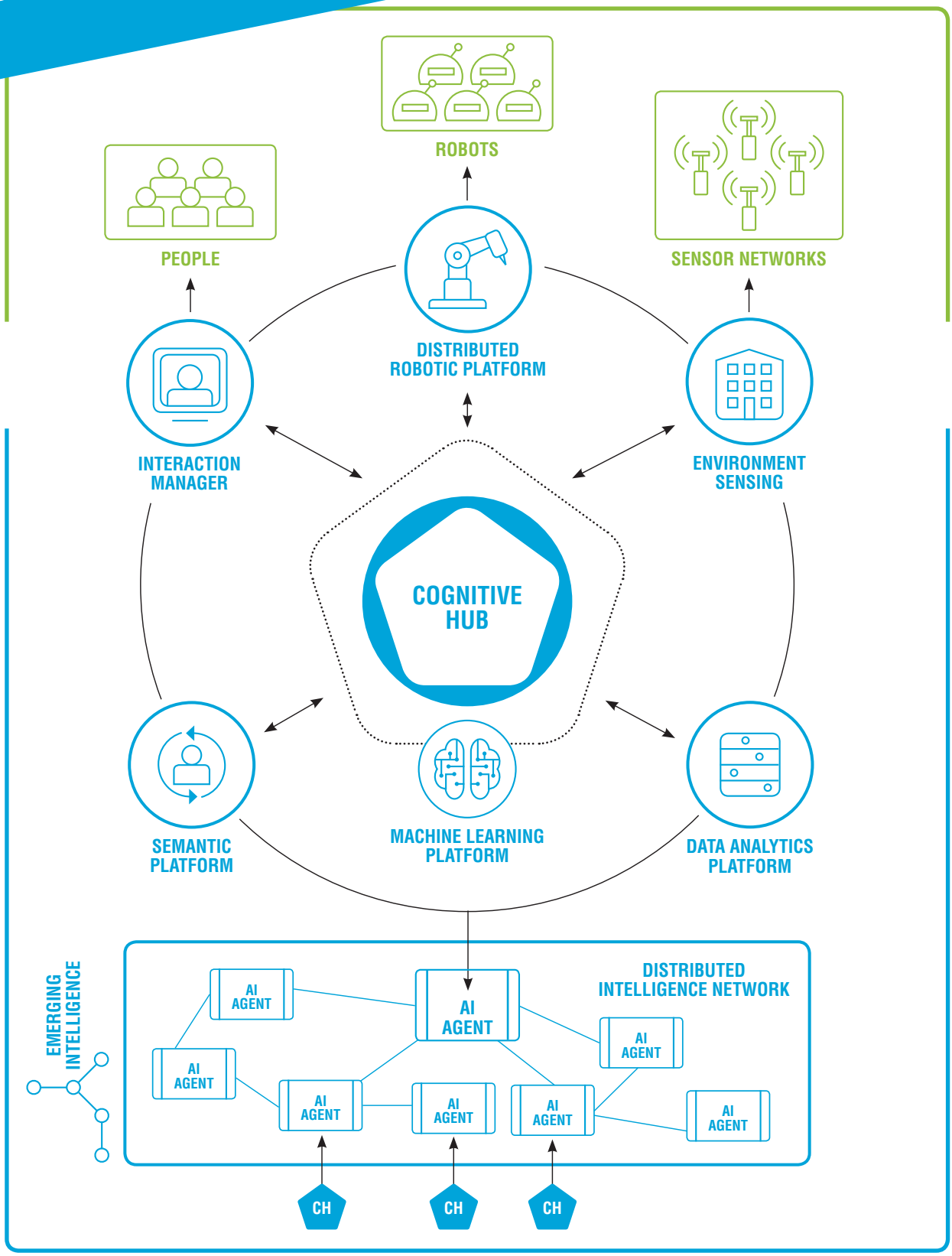
Social and companion robots. Whilst industrial and medical robots have an established presence in their fields, robots with comprehensive social skills that are able to interact naturally with people and spaces, are now also experiencing a revolution. The increasing advances in artificial intelligence enable social and companion robots to act and perform in spaces that were designed for humans; they can learn, understand and interact with people in a natural way. At Konica Minolta we are developing an ecosystem for social robots that naturally interact with different environments and with people. Through services that will expose these robots to artificial intelligence, Cognitive Hub will provide the means for social and companion robots to become more effective and resource-rich.

> "Our vision is to create a range of services to support robots in applications for the office, medical and manufacturing domains, linking IoT devices, data analytics, artificial intelligence and cloud and hybrid computing."

[5] For instance, Intuitive Surgical Da Vinci Surgical system https://www.intuitivesurgical.com

[6] "Insights from Data", January 2018 http://research.konicaminolta.eu/white-papers/insights-from-data-ai-for-medical-imaging/

Cognitive Hub and the Digital Cortex



Our vision: A platform for distributed robotics

Cognitive Hub is a platform of platforms defining a federated system capable to orchestrate AI services and agents for the workplace of the future. The goal of this platform is to extend the network of human interfaces, enhancing the collaboration amongst individuals and teams, and ultimately providing augmented intelligence-based services that are immediately and automatically actionable[2]. Cognitive Hub relies upon the *digital cortex* [3], a membrane permeated by AI, mapping the network of people, devices and spaces to the digital world.

As part of Cognitive Hub, our distributed robotic platform will enable robots to connect and interface to this digital cortex. With the increasing need for intelligent robots to operate in complex physical and social environments, we are developing a unified platform that can act as an orchestrator and integrator of physical robotic systems to the digital world, providing the context for unstructured environments and social interactions to connect to robotic systems.

Cognitive Hub bridges human reality and our physical environment to a digital representation and so enables us to seamlessly integrate robots within different workflows. At the same time it permits robots to be active entities that can contribute towards mapping out the physical environment and therefore provide a whole new set of data about the physical world. These are the core characteristics that form the Cognitive Hub distributed robotic platform:

Cognitive support. The increasing availability and complexity of different sensors that are intelligently connected by sensor-fusion technologies to combine their data are augmenting the spectrum of tasks that robots can perform. This is made possible through the ability of machine learning to transform the raw data input into control signals. Cognitive Hub orchestrates a Machine Learning platform that extracts actionable insights from multiple data sources and makes them available to robots at the right time.

Broadening the digital environment. Connected robotic systems will enrich the digital environment, creating new forms and new types of data and information, from their interaction with the physical world and their ability to explore it. Haptic and three-dimensional force feedback devices, touch sensors and depth sensors are only some of the key enabling technologies that are supported by Cognitive Hub.

Interoperability. The distributed robotics platform provides low-level solutions for interconnecting sensors technologies and physical robots to the Cognitive Hub infrastructure. It supports the main existing software robotic platforms, such as the Robotic Operating System (ROS), and interfaces with more advanced cognitive robotic platforms commonly used for humanoid robotics, such as in iCub[4] .

Emerging collective intelligence. With multiple robots connected through the digital cortex and empowered by artificial intelligence a new layer of intelligence can emerge. Cognitive Hub will enable both software and physical agents (i.e. robots) to interact with each other, creating multi-agent systems. Such systems can be used to solve problems that are impossible for a single system. Applications of multi-agent systems include:

- collective and collaborative intelligence, i.e. intelligence emerging from collaboration within a distributed system;
- swarm intelligence, i.e. decentralised agents that can self-organise collectively to target a desired behaviour.

[2] "Cognitive Hub: the OS for the workplace of the future" September 2017 http://bit.ly/Cognitive-Hub

[3] "The evolution of AI in workplaces", September 2016, http://bit.ly/evolution-of-AI-in-workplaces

[4] iCub.org An open source humanoid robotic Cognitive Platform http://www.icub.org/

Talk to us

Konica Minolta's research in our laboratories in Europe, Japan and the United States brings together the various platforms that will form Cognitive Hub. Please get in touch if you are interested in further discussions around developing platforms for distributed robotic systems.

http://research.konicaminolta.eu
http://artificial-intelligence.konicaminolta.eu
research@konicaminolta.eu

KONICA MINOLTA

Laboratory Europe

Konica Minolta Laboratory Europe - Konica Minolta Inc.
90 Chancery Lane, London,
WC2A 1EU,
United Kingdom

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