Robotics for Healthcare

Personalising care and boosting the quality, access and efficiency of healthcare

Potential of Robotics

The value of robotics for healthcare could be huge in terms of health, societal and economic benefits. Robotics offer the promise of sustainable and affordable health provision without compromising quality of care. Some products are already available, like the surgical robot Da Vinci, but this is just the beginning. Clear roadmaps are required for the scale of research and development still needed to transform the challenges that exist – technological, financial, ethical, social – into practical and beneficial solutions. The potential is tremendous.

Research Roadmaps for Robotics

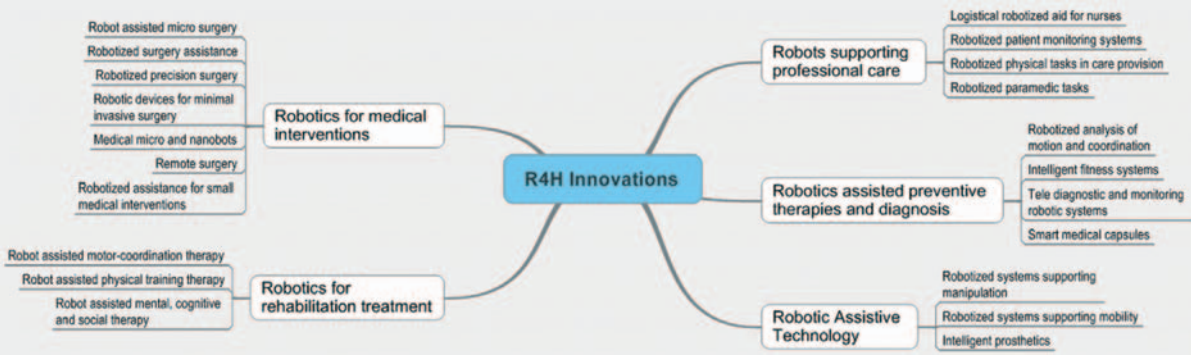
The basic idea of roadmapping is to look for the best way to arrive at a destination. In healthcare, this means dealing with the societal issues, diseases and other medical conditions, which healthcare systems need to cure, care for or prevent, both now and in the future. In relation to robotics, this concerns questions such as which robotic applications will be valued additions to healthcare, which products can meet market needs and which technologies are needed to accomplish them. Some technologies are available, while others need a lot of research and development before they can be applied to the production of a robotic system.

Six of the Best

Consultation with experts and stakeholders has identified 21 main innovation areas that can be considered key product/market combinations and from which six representative areas can be regarded ripe for further investigation and roadmapping:

- Smart medical capsules
- Robotised surgery
- Intelligent prosthetics
- Robotised motor coordination analysis and therapy
- Robot-assisted mental, cognitive and social therapy
- Robotised patient monitoring systems;

Each of these specific areas needs to be considered in respect of the key stakeholders and their motives, the key technologies and related research challenges, the expected societal and institutional developments as well as future market trends in order for a roadmap to be drawn up.



In the Robotics for Healthcare domain five innovation themes are identified consisting of 21 innovation areas. Innovations are products/ services, processes or systems that address a medical/societal need or tackle an emerging issue. An innovation area is a group of related product/ market combinations.

Smart medical capsules

A means of 'journeying' through the body in a way that causes less discomfort than traditional endoscopy where invasive probes are used. The smart capsule endoscope is a 'pill' that is swallowed and then makes pictures of internal systems such as the intestines, while travelling through the body. Robotising the capsules boosts greatly their diagnostic and therapeutic effectiveness and signifies a radical change in medicine. A minirobot (and in the future perhaps a "nanobot") will be able to move itself, or be externally steered, to have a closer look at internal tissues, take samples or even destroy unwanted tissue.

Case in point: *In the future, minirobots could be introduced into the eye to perform precision eye surgery under the external control of the surgeon.*

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Robotics for Medicine and Healthcare is the application of technology whereby systems are able to perform coordinated mechatronic actions (force or movement) on the basis of processing information acquired through sensor technology.
These systems cooperate safely with humans and support the functioning of impaired individuals, medical interventions, care and rehabilitation of patients as well as participation of individuals in prevention programmes.

Robotised surgery

Robotised surgery will facilitate new types of intervention, e.g., in areas of the human body that are difficult to access. Precision, durability and repeatability enable automation of surgical tasks and facilitate minimally invasive surgery, remote tele-surgery, preoperative planning, surgical training, intra-operative navigation (image-guided surgery) and surgical simulation all from one place. The future: the integration of different robotic systems in broader platforms to assist surgeons and perform surgery autonomously.

Case in point: *The Da Vinci surgical robot helps the surgeon, who sits at a special console, to perform very precise minimally invasive surgery procedures.*

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Intelligent prosthetics

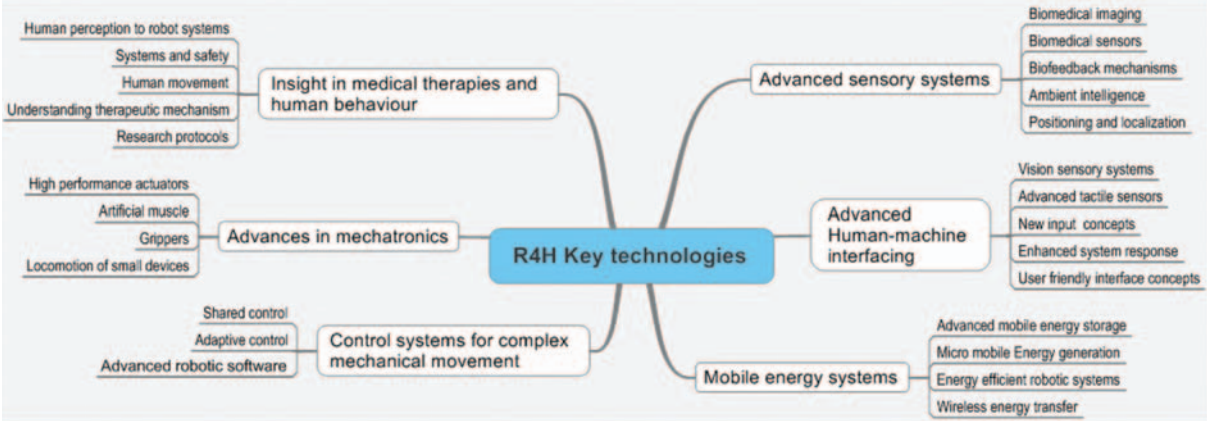
Control systems that facilitate natural movement and intuitive control of arm and leg prostheses, preferably with the same subconscious control as for natural limbs. The future: system autonomy (control by peripheral nervous system) and brain interfacing.

Case in point: *A future development: the newest experimental hand prosthesis from Otto Bock with individual movement of fingers controlled by nerve signals.*

© Otto Bock/A.Kromus

Key messages

- **Robotics hold the promise of addressing some major healthcare issues.**
- **The field of robotics in healthcare is in its infancy – industry, government and research can still exert influence.**
- **There is a need to bridge the difficult transitions from laboratories to trials and from trials to regular healthcare practice.**
- **Systematic support to research is needed for progress to be made.**
- **Addressing ethical and legal problems should be an integral part of any research programme in this field.**
- **Awareness must be raised through a flanking communication programme.**



26 enabling technologies are identified. These are existing or future scientific or technological areas of expertise that are needed for the realisation of innovative robotic systems.

Robotised motor coordination analysis and therapy

In the treatment of patients with traumatised motor control, for example following stroke, robotised analysis and therapy of motion offers additional support to the training given by a physical therapist. These robotic systems evoke preinstalled movements or mirror movements for which unaffected control is still available, thus opening the way to the restoration of central motor coordination. These systems will be able to identify and assess dynamic movements as well as coordination disorders. The application of these systems supports the development of insight into the mechanisms underlying human motor coordination that are currently not well understood. The future: systems that provide personalised therapy through user recognition and the application of virtual reality and haptic feedback technology.

Case in point: *The Locomat from Hocoma makes it possible to offer individually tailored and adaptable treatment to stroke patients undergoing therapy for restoring motor coordination.*

© Picture courtesy of Hocoma AG, Switzerland

Robot-assisted mental, cognitive and social therapy

Social interaction of people with mental, cognitive and social handicaps (e.g., autistic children or elderly people with dementia) is essential to their social participation but proves to be a major challenge for healthcare. Robotised systems can support human care and offer unprecedented therapeutic functionality that will develop or maintain social skills which would not be available without these systems or would vanish. Results can be expected in terms of developing basic social skills through play or maintaining skills to deal with everyday life. These robotic systems can be programmed to generate all kinds of communicative reactions (e.g. sounds and colours), invite to move or play games, stimulate friendly face expressions and can also learn to adapt to the individual person.

Case in point: *Kaspar is a robot which provokes playful reactions with therapeutic effects for children with autism.*

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Robotised patient monitoring systems

Presently, monitoring devices help doctors and nurses to look after patients. This is especially valuable when the patient is at home. However, when unusual situations are detected, it is often difficult to tell from a distance how urgent the situation is, which means that the doctor or nurse has to go to the patient's home. Robotising the present systems will enhance communication and identification of alarming situations. The future will see more remote monitoring and this will help care to become more affordable and efficient.

Case in point: *The Care-o-bot monitors patients and helps them with daily routine activities at the same time.*

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ROBOTICS FOR HEALTHCARE

Europe has an excellent opportunity to lead the world in robotics for healthcare

Revolutionary Robotics

Significant progress has been made in medical science in the last decades but major challenges still exist. People live longer, but often at the expense of additional years with a chronic disease. Patient safety is a hot topic and health expenditure is ever-increasing. With numbers of health professionals on the decline, the situation is disconcerting.

Robotics can offer solutions, not for every aspect of every problem but for a significant proportion, especially for patient groups such as amputees, stroke sufferers or people with cognitive or mental problems. Many more innovations are expected by around the year 2025, though four application areas that cover a large field of healthcare are on the near horizon:

- A revolution in surgery by all kinds of robotic systems;
- Developments in diagnostics, through the evolution of more intelligent and multi-functional endoscopic capsules;
- Greater autonomy and independence for people with illnesses and disabilities at home through the introduction of domestic robots, first for monitoring, later for support tasks;
- Robotic systems in nursing care to support the arduous work of the individual professional and to counteract the imminent staff shortages.

Robots are very complex systems; not all the necessary knowledge is available at the right level and, as a result, innovation processes are rather complex too. This complexity exists not only in terms of all the technologies that have to be integrated faultlessly into a single device but also in terms of regulation and implementation in healthcare. Many stakeholders have to cooperate in new roles and combinations or have to take the initiative to support the application of robotics in healthcare. Ethical and legal aspects are likely to pose obstacles to the developments at some point. However, these can be overcome if all relevant stakeholders are involved in the processes at the right time and in the right way.

The market is not only European but global. The quality and broad interest of the research programmes in the EU suggests that Europe has an excellent starting position and a good opportunity to lead the world in this area, which will generate major benefits for the European industry as well as social and economic welfare for its citizens. It is a field of innovation that encompasses many interesting leads, problems to be solved and challenges to be met. But, given the health-related, social and economic significance, the effort for getting involved in this field is well worth it in the long term.

The Robotics for Healthcare study was funded by the European Commission, DG Information Society and Media, with the aim to investigate and develop a roadmap for the application of robotics in medicine and healthcare.

A consortium led by TNO Quality of Life has developed the roadmap. The consortium also includes Vilans (the Netherlands), VTT (Finland), ISI Fraunhofer (Germany) and EuroAct (Japan), and has been assisted by a large international group of experts. The project started in April 2007 and was completed in June 2008.

More information on ec.europa.eu/information_society/ehealth and www.tno.nl/robotics_for_healthcare

TNO Vilans EUROACT VTT Fraunhofer ISI Institute Systems and Innovation Research

European Commission Information Society and Media