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Roadmap Robotics for Healthcare

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Purpose

The main aim of this study was to provide key research policy recommendations for the application of robotics in healthcare in the research programmes of the EC. The study also aimed at raising awareness about important new developments in this field among a wider audience. To this extent, a roadmap of promising applications of robotics in healthcare and associated R&D was developed, taking into account the state of the art as well as short and long-term future possibilities with a time horizon ending in 2025.

Targeting Future Research Programmes of the EC

Why Robotics for Healthcare?

For the last two decades, the European Commission (EC) and, in particular, the Directorate General Information Society and Media have strongly supported the application of information and communication technologies (ICT) in various sectors of society by means of their research programmes (as part of the consecutive Framework Programmes).

The EC sees healthcare as an important domain, where ICT can play a key role in solving societal issues. Challenges like the reduction of labour costs, improving quality of care and longer independent living of the elderly exemplify just three examples where ICT can play an important role. These challenges are expected to grow in the face of demographic developments (ageing of patients and personnel), epidemiological developments (e.g. increase in chronic illnesses), expected shortages of healthcare personnel, demand for improving the quality of life for the elderly, chronically ill and disabled, and the demand for a further increase in the quality of medical care, enabled by new technologies such as high precision surgery.

On the other hand, robotics is still an emerging field of technology. Due to the further miniaturization of crucial key technologies like sensors and actuators, robotics now enters the second stage of development. Some visionary experts, such as Bill Gates, are already talking about a new technology wave following biotechnology.

The combination of healthcare and the new developments in robotics create opportunities to stimulate innovation in the domain of robotics for healthcare. Several programmes and networks dedicated to research on robotics are already focusing part of their efforts on applications in healthcare.

What Is “Robotics” and What Area Is Studied?

In this study, robotics is considered the domain of systems able to perform coordinated mechatronic actions (force or movement exertions) on the basis of processing information acquired through sensor technology, with the aim of supporting the functioning of impaired individuals, medical interventions, care and rehabilitation of patients and also individuals in prevention programmes.

The focus of the study is on solutions that support the key objectives of healthcare:



- To contribute to quality, safety and efficiency of care.
- To promote the shift to preventive and personalized care.
- To support the availability of long term care for people in need.

Because the application of robotics in healthcare is not only an issue of technology but also heavily depends on societal acceptance, safety and reliability issues as well as regulations, special attention was paid to these aspects.

Methodology and Deliverables

According to the EC specifications, the required methodological approach for this study included literature research, surveys and interviews with experts and stakeholders as well as an evaluative workshop with a representative group of experts and stakeholders for drafting the roadmap.

The study was divided into four work packages (diagram below):

- The development of a state-of-the-art analysis report
- Development of a roadmap consisting of six sub roadmaps
- In depth analysis based on three case studies (from the six sub roadmaps)
- Evaluation of results in an expert workshop

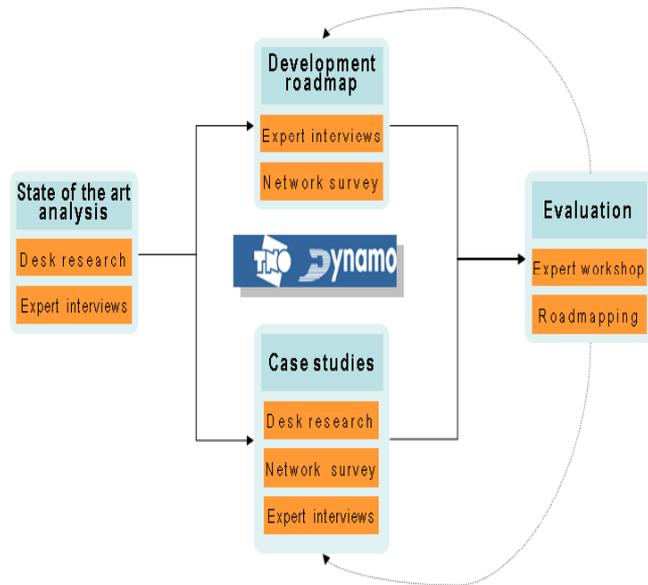


Figure 1: Overview of the approach

During the project, desk research was complemented by consulting more than 50 internal and external experts.

The state-of-the-art report (SOTA report) presented the state of the art in robotics for healthcare on a large number of applications and enabling technologies.

A catalogue was developed with over 300 applications and 100 organizations developing robotics (for healthcare). These were stored and profiled in the Dynamo database.

Based on the research, 25 innovation areas were identified. Out of these, six innovation themes were further analyzed. For three areas a case study was developed. These were chosen in close consultation with the EC in order to provide further insights on the driving factors of and barriers to the development of robotics for healthcare, the role of the stakeholders and possible ethical and legal issues.

In this way six draft roadmaps were developed. They were evaluated during a two-day expert workshop with 45 experts. The results of the workshop were used to finalize the roadmaps.

With regard to dissemination and raising awareness beyond the closely involved experts, a brochure was developed to be distributed amongst the relevant community.

Major Findings: Six Innovation Areas

During the analysis of the field of robotics for healthcare, *five innovation themes* were identified:

- Robotics for medical interventions
- Robotics supporting professional care
- Robotics assisted preventive therapies and diagnosis
- Robotics assistive technology
- Robotics for rehabilitation treatment

Within these innovation themes, 21 *innovation areas* were identified, as shown in Figure 2 (see page 3).

Based on a survey among stakeholders and in close cooperation with the EC, the six most relevant innovation areas were selected as potential priorities for the EC in their Framework Programmes, based on the criteria *market and industrial potential* and *relationship to the e-Health domain*:

- Smart medical capsules (for endoscopy, biopsy and targeted drug delivery)
- Intelligent prosthetics for upper and lower extremities
- Robotized patient monitoring systems
- Robotized surgery (a combination of the areas related to the facilitation of the surgeon in the operating room)
- Robotized motor coordination analysis and therapy
- Robot assisted mental, cognitive and social therapy

Mapping Key Technologies for Robotics in Healthcare

Robotic systems are very complex. They depend on many enabling technologies and pose many challenges of how to integrate these into a functional system. These technologies and challenges require a significant amount of R&D, are dependent on each other and progress at different speeds. Human-machine interface designs, sensor systems, mobile energy supply, energy efficiency and biocompatible materials are some of the main topics. The key technologies identified are presented in Figure 3.

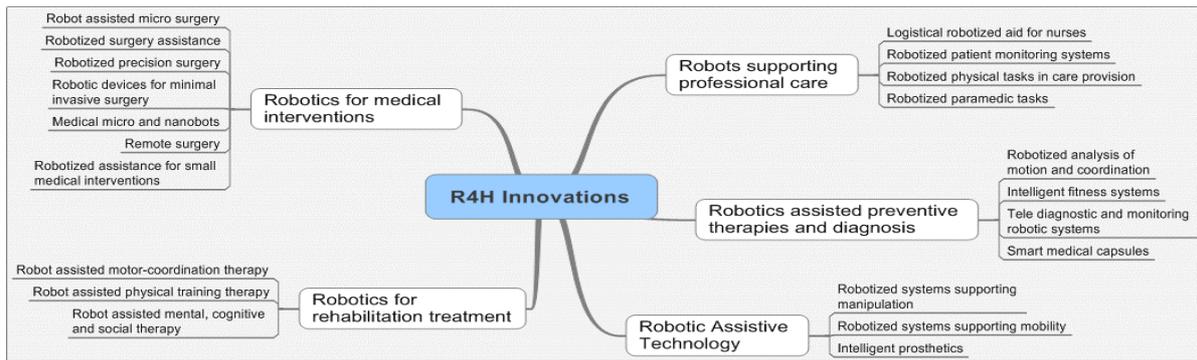


Figure 2: Innovation areas

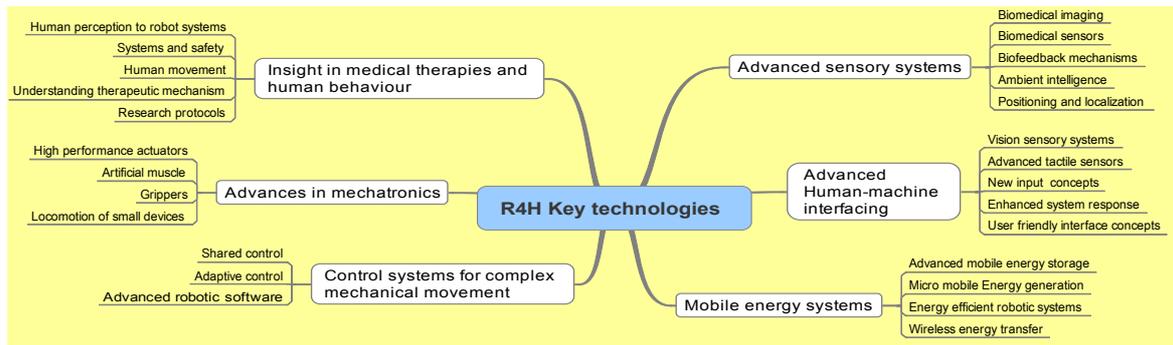


Figure 3: Key technologies for application of robotics in healthcare

Constructing the Roadmaps for the Six Innovation Areas

During the two-day workshop with stakeholders the findings about the six selected innovation areas and key technologies were discussed and integrated into a roadmap diagram. As an example, the roadmap of one of these innovation areas, smart medical capsules, is shown in Figure 4 (see page 4).

The Potential of Robotics in Healthcare and the Role of Stakeholders

The field of robotics for healthcare is driven by the expectation that robots will be able to play an important role in helping societies to cope with a number of the big challenges and trends of the next decades. The study has shown that the application of robotics in healthcare is in many areas a young but promising field with different segments progressing at different speeds. Only a few products have actually reached the stage of large-scale market introduction, the real measure for successful innovation. Many applications are still very expensive. In many instances, it is quite difficult to identify the reasons for discontinued and unsuccessful projects, since multi-dimensional factors like legal issues, regulations, enabling technologies, social acceptance and unforeseeable disruptive incidents play key roles.

The first commercial products on the market may serve as a signal for a greater development to follow. The market is expected to grow, as the following examples indicate. The U.S. market for prosthetics, orthotics and cosmetic enhancement products is expected to increase from \$6.8 billion in 2005 to \$10.8 billion in 2010. Smart medical capsules may even take over the whole market for classic colonoscopy screenings, as prices for smart medical capsules will drop below the current \$450 per unit.

Since the overall sector of robotics in healthcare is still an emerging area with successes and failures, a final conclusion about the future trajectory cannot be made at present. Nonetheless, the identification of drivers, barriers and challenges is helpful to guide the development into a desired direction for achieving higher quality, safety and availability of care and a shift to prevention.

From the side of the stakeholders, e.g. patients, doctors, hospitals, care institutions, health insurance companies and authorities, it appears that most of them see the developments as very interesting for the future, but very few of them show any urgency to switch to these new applications right now.

The role of suppliers is becoming more important, as it should, but patient involvement in research and development is (too) little. Although government is not considered a key market player in this area, governmental funding for related R&D is crucial.

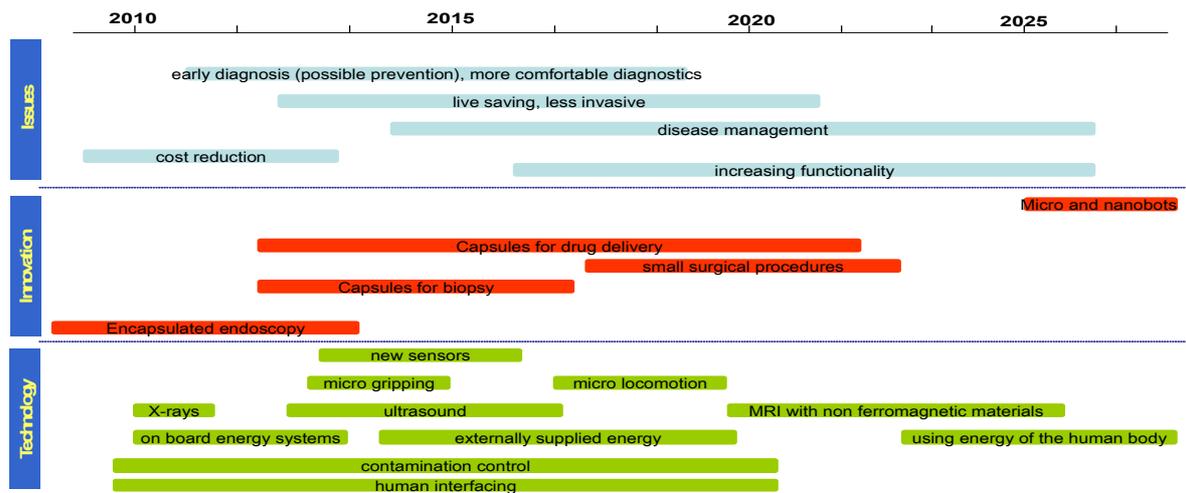


Figure 4: Example of a roadmap diagram for smart medical capsules

Key Policy Recommendations

Given the findings, the main recommendation to the EC is to further develop this area in the Framework Programme. This recommendation is strengthened by the fact that only a few research programmes exist that specifically focus on this area. Further arguments to support this conclusion are:

- The field is *still in its infancy*, but some products are already commercialised. This supports the conclusion that there is a market but that this market has just entered its growth phase.
- The "Robotics for Healthcare" network in Europe is relatively small, but the authors believe that it has *critical mass* (both within research and industry).
- Robotics is seen to be the origin of the *next potential Kondratiev* wave. Therefore, further influential developments in the field can be expected, also boosting other areas.
- Looking at the broad enabling robotic technologies, *cooperation* with other robotic application fields should be facilitated (e.g. through the EURON network).
- The field also needs the further enhancement of the "Robotics for Healthcare" network to establish a sound *multidisciplinary* community.
- The model of innovation used should incorporate not only research but also a *combination* of research, development and application to ensure actual use of the research.

- To be an effective program, it would be advisable to add "*horizontal*" lines to the programme: one on legal and one on ethical issues.
- Because the field is very new, acceptance and implementation will be complicated. To raise awareness and promote involvement of stakeholders, *awareness activities* should accompany any innovation programme.
- The current methodology to prove the effectiveness of medical interventions with robotic systems seems very burdensome and costly. Methodology, like evidence-based medicine, originally designed for medicines, should be *adapted* to the characteristics of (robotic) devices.
- The programme must include some mechanism that guarantees that it not only attracts researchers interested in long-term possibilities, but also companies and/or health institutes that have an urgent interest in practical applications.

Impact and Policy Implications

The final report and all the other deliverables from the projects have been well accepted and approved by the European Commission in October 2008. Parts of the results have gone into the further development of the working programmes of FP7 and the new FP8.

In the Netherlands, the results are being used for further development of a TNO vision of TNO's role within robotics for healthcare and have also initiated discussions at several ministries.

Sources and References

The final report and an illustrated brochure about the project have been made available on the website of the EC. Information about the other deliverables can be obtained from the project leader (maurits.butter@tno.nl).

About the EFMN: Policy Professionals dealing with RTD, Innovation and Economic Development increasingly recognize a need to base decisions on broadly based participative processes of deliberation and consultation with stakeholders. One of the most important tools they apply is FORESIGHT. The EFMN or European Foresight Monitoring Network supports policy professionals by monitoring and analyzing Foresight activities in the European Union, its neighbours and the world. The EFMN helps those involved in policy development to stay up to date on current practice in Foresight. It helps them to tap into a network of know-how and experience on issues related to the day to day design, management and execution of Foresight and Foresight related processes.