Dutch Robotics Analysis

Strategic Agenda RoboNED part 1

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Preface

How can we tackle the societal challenges we are facing in the coming years? How can we create real value for our economy and real services to our society? There are good reasons to believe that these crucial and fundamental questions can be addressed at least partially by robotic technology. RoboNED is trying to better understand how robotics in the Netherland could be shaped in order to yield an ecosystem able to address these goals.

RoboNED was born as one of the ICT-platforms in 2010 and intended to deliver a roadmap with an analysis and concrete suggestions on how to achieve the described goals. This document is a first contribution to this goal and is the result of multiple iterations among the key-players in the Netherlands. Robotics is a large multi-disciplinary field including many key technologies and with a very broad applications field. The analysis up to this point has been addressed from the side of the market and application fields and for this reasons a number of key markets have been identified and studied.

A SWOT-analysis has been used to try to achieve an objective and unbiased overview of the field potentials for the Netherlands. Such an analysis is the result of team work and investment of time of many people. I am greatly thankful to all people that have contributed to this important goal. I would like to thank the management team of RoboNED for their continuous support and time investment, but especially like to thank Ditske Kranenburg who has played the crucial main editorial and coordination role as platform manager. Ditske's devotion and professionalism have been outstanding.

The creation of the complete SRA is not completed and before the time frame of completion of the ICTRegie contract this will be achieved, but that will not be the end of RoboNED. RoboNED will have to keep on playing the role of representing body for Robotics in the Netherland and interface between the field and policy maker, and will have to keep his goal as catalyzer for achieving the vision and goals named before. I will take a personal responsibility in order to do that and I hope that together we will manage to place the Netherlands as one of the major contributors on the international scale to tackle the great challenges our modern society is going to face in the coming years.

Stefano Stramigioli
Chair of RoboNED

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Executive Summary

Economical Aspects

The foreseen economic prospects for robotics markets are rapidly increasing. In an international context, success stories are seen like the US enterprise I-Robot that besides the introduction of the successful Roomba vacuum cleaner is applying different robotics technologies for service and defense. The Japan Robotics association predicted that the robotic market size in 2025 will be 66.4 billion dollars, twice the current one and more than two third of it will be dedicated to Personal and Service robotics, as shown in Figure 0.1[iv]. This prediction correspond to the findings of the International Robotics Federation. This foundation predicts a large growth of service robots for professional use and personal use in the period 2011-2014[xiii]. The milking (bio-agro) robots and defense applications make up 55% of the total forecast of service robots for professional use. In the field of personal robots domestic and entertainment robots are a fast growing market.

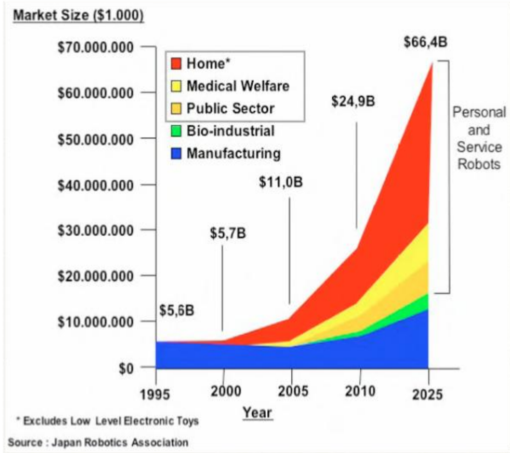


Figure 0.1: Predicted Robotic Market[iv]

At national level there is enormous potential due to the high tech industries, with companies such as Philips, ASML, Thales and NXP. Philips is an important player in the field of service robots and develops, produces and sales o.a. robotic vacuum cleaners. The Netherlands has a lot of SME companies involved in robotics, like Demcon which realizes high-tech mechatronic systems and products e.g. applied in healthcare robotics. Other companies selling and developing robots are for example Focal Meditech, Assistive Innovations and De Koningh Medical Systems. A real leading position for the Netherlands is the dairy and cattle market which extensively uses robotics, for a large part provided by the international operating company Lely. Another robotic market is agriculture, where for example companies like Jentjes and Aris are active. This market is very important due to the leading position of the Netherlands in this market in terms of productivity and efficiency.

Social-Cultural Aspects

The Dutch society will have a large problem in due time in providing healthcare, agriculture and industry with enough personal to keep the economy running. In 2050 it is forecasted by CPB that the amount of people above 65 years old in the EU is 50% in comparison to people of 15-64 years old. Robotics might provide a solution for this problem. In healthcare, this problem is the most urgent due to combination of this problem with an increasing need for care. Care robots can take over tasks where human understanding and contact is not necessary or even not wanted, like assisting in toileting. A care robot can also be very helpful in assisting in heavy fysical work, like lifting people. In this way we are able to be more careful with our care profesionals.

Agro-robotics enables a sustainable development of agricultural production by solving challenges like shortage of labor, growing production costs, competition on the international market, poor labor conditions, poor labor image, food safety and product quality and efficient use of resource and reduction of emissions of chemicals to the environment. Without the use of robots in agriculture the current up-front position in this sector might be lost.

Technological Aspects

Investments might not only be necessary for healthcare and agriculture but might also be beneficial for the total innovation power of the Netherlands. Internationally, the Netherlands is highly rated in the field of high-tech mechatronic research and has a good representation with innovative technological companies. The links between companies and knowledge institutes are direct and short. These ingredients provide a unique chance to collaborate in the development of technology into commercial products.

Technological area's, in which research should be increased and collaboration is indispensable, are:

- Navigation and Motion Planning;
- Sensing and Perception;
- Compliance and Interaction Control;
- Human-Robot Interaction and Haptics;
- Learning and Adaptive Systems;
- Energy and Lightweight Materials;
- Software Engineering for Robotics and Automation;
- Safety for Service Robots.

Ethical, Legal and Educational Aspects

Beside technological investments, there are important non-technological investments necessary. A common problem for every application domain is the shortness of engineers able to develop robots, in addition to clear and focused business cases (winners). On a different level, people should be educated to be able to work with robots. Educational institutes should provide their students a curriculum that is adjusted to the future working environment, including the use of robots.

To provide a good integration of robots in society, legal issues like liability should be clearly defined and a safety mark for robots should be further developed. Hence, acceptation of robots can be stimulated by these measures. The public discussion on the ethical issues of robotics should be run based on knowledge and reality.

Conclusions

In particular in health and agro&food, robotics will be indispensible in the future. In these fields robotics is a great opportunity. Cross-domain collaboration on technological and economical challenges will be a key-issue. Therefore, it is of great importance to the development of robotics that the existing eco-system will be further developed and academia-industry collaboration will be improved in order to transfer the opportunities into commercialized products.

Samenvatting

Economische kansen

De economische vooruitzichten voor de roboticamarkt zijn snel aan het toenemen. Op internationaal gebied zijn er succesverhalen zoals het Amerikaanse bedrijf I-robot. Niet alleen de introductie van de Roomba robotstofzuiger is succesvol, maar ook de verschillende toepassingen van robotica technologie voor service en defensie. De Japanse robotica associatie voorspelt dat de roboticamarkt in 2025 66.4 miljard dollar zal zijn[iv]. Dit is een verdubbeling van de huidige markt en twee derde hiervan zal bestaan uit persoonlijke en service robots (zie figuur 0.2). Deze voorspelling wordt onderstreept door de bevindingen van de Internationale Robotica Federatie. Zij voorspellen dat in de periode 2011-2014 een grote groei van service robots voor profesioneel gebruik en persoonlijk gebruik zal plaatsvinden[xiii]. De melkrobots en defensie toepassingen vormen samen 55% van de voorspelde groei in het totaal aantal service robots voor professioneel gebruik. Op het gebied van persoonlijke robots gaat het om een grote groei in de huishoudelijke robots en entertainment robots.

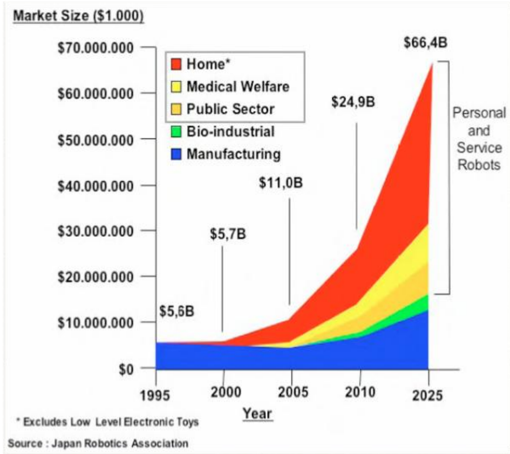


Figure 0.2: Predicted Robotic Market[iv]

Op **nationaal niveau** heeft Nederland enorme potentie met haar high tech industrie, met grote bedrijven als Philips, ASML, Thales en NXP. Philips is een belangrijke speler in de service robotica en ontwikkelt, produceert en verkoopt o.a. de stofzuigrobots. Ook zijn er in Nederland veel MKB bedrijven die deel uit maken van de robotica markt. Het bedrijf Demcon realizeert hightech mechatronische systemen en producten waarbij een van de belangrijke toepassingsgebieden de gezondheidszorg is. Andere bedrijven die medische robots verkopen zijn o.a. Focal Meditech, Assistive Innovations en De Koningh Medical Systems. Nederland heeft een leidende positie in de melk- en veerobotica, welke voor een groot deel wordt verzorgd door het bedrijf Lely. Een andere roboticamarkt is de agrarische robotica, waar bijvoorbeeld bedrijven als Jentjes en Aris actief zijn. Juist voor Nederland is dit een belangrijk markt vanwege de al vooraanstaande positie die Nederland heeft in de landbouw in termen van grote productiviteit en efficientie met nadruk op de tuinbouw en veehouderij.

Maatschappelijke kansen

De maatschappelijke kansen liggen in Nederland onder andere op het gebied van het te verwachte te kort aan personeel in de zorg, landbouw en industrie dat binnenkort zal ontstaan. In 2050 zal volgens de voorspellingen van het CPB het aantal 65+ers in de EU 50% zijn ten opzichte van 15-64 jarigen.

Zorgrobotica kan een oplossing bieden voor de toenemende vraag naar zorg en een afname van het aantal zorgprofessionals. Zorg robots kunnen ingezet worden op een dusdanige manier dat taken waar menselijk inzicht en contact voor nodig is ook daadwerkelijk door mensen uitgevoerd kan blijven worden. Daarnaast kunnen robots assisteren bij fysiek zwaar werk van zorgprofessionals, zodat Nederland zuiniger kan omspringen met de zorgprofesionals die we hebben.

Agrorobotica kan een duurzame ontwikkeling van landbouwproductie bewerkstelligen door het oplossen van uitdagingen als het te kort aan personeel, de groeiende productiekosten, concurrentie op de internationale markt, slechte werkomstandigheden, slecht imago van het werk, voedselveiligheid en productkwaliteit en efficiënt gebruik van grondstoffen en het terugdringen van de uitstoting van chemicaliën in het milieu. Zonder de inzet van robots in de landbouw kan Nederland zijn huidige vooraanstaande positie verliezen.

Technologische kansen

Investeringen in robotica zullen niet alleen nodig zijn voor de gezondheidszorg en de agrarische sector, maar zal de gehele innovatiekracht van Nederland vergroten. Nederland staat internationaal zeer hoog aangeschreven op het gebied van hightech mechatronica onderzoek en heeft een goede vertegenwoordiging van innovatieve technologische bedrijven. Daarnaast zijn de verbindingen tussen de bedrijven en onderzoeksinstellingen kort. Deze ingrediënten maken het tot een unieke kans voor Nederland om de gezamenlijke technologische ontwikkelingen ook daadwerkelijk te laten leiden tot succesvolle producten waar de BV Nederland aan kan verdienen.

Technologische gebieden waarin het onderzoek zou moeten worden vergroot en waarin samenwerking onmisbaar is, zijn:

- Navigatie en Bewegingsplanning;
- Sensoren en Perceptie;
- Compliantie en Regeltechniek;
- Mens-Robot interactie en Haptics;
- Lerende en Adaptieve Systemen;
- Energie en Lichtgewicht Materialen;
- Software ontwikkeling voor Robotica en Automatisering;
- Veiligheid m.b.t. service robots.

Onderwijs, Juridische en Ethische kansen

Naast de technologische investeringen zijn belangrijke aandachtspunten:

- Educatie van robotontwikkelaars en gebruikers;
- Regelgeving omtrent de verantwoordelijkheid en veiligheid;
- Maatschappelijke en ethische aspecten.

Conclusies

Robotica is in de nabije toekomst onmisbaar in met name de zorg en agro&food. Nederland kan deze kansen niet voorbij laten gaan en moet de wetenschappelijke en economische uitdagingen gezamenlijk aangaan. Het is van groot belang voor de ontwikkeling van de robotica in Nederland, dat het ontstane ecosysteem niet verloren gaat en dat de kansen die Nederland heeft, benut worden en op deze manier ook daadwerkelijk tot versterking van de hightech industrie van Nederland leiden.

1 Introduction

1.1 Problem Definition

The foreseen economic prospects for robotics markets are rapidly increasing. In an international context, success stories are seen like the US enterprise I-Robot that besides the introduction of the successful Roomba vacuum cleaner is applying different robotics technologies for service and defense. Another example of a success story is the Da Vinci robot for minimal invasive surgery by the US enterprise Intuitive Surgical. The Robotics Japanese association predicted that the Robotic Market size in 2025 will be 66.4 billion dollars, two times the current one of which more than two third will be dedicated to Personal and Service robotics (see Figure 1.1). These predictions are also shared by distinguished business men like Bill Gates, who in an article published in Scientific American[i], predicts that robotics will make the same market evolution that the PC did becoming pervasive in our society. In the 2008 Dutch Horizon Scan report[ii], the importance of robotics is clearly recognized. In IEEE Spectrum[iii], the spread of industrial robots around the world is shown, see Figure 1.2. Originally, robots are used in the automotive industry, but are now commonly used in production manufacturing processes. The (potential) growth of the other application areas of robotics brings both scientific and technological challenges and also economical opportunities for the Dutch society.

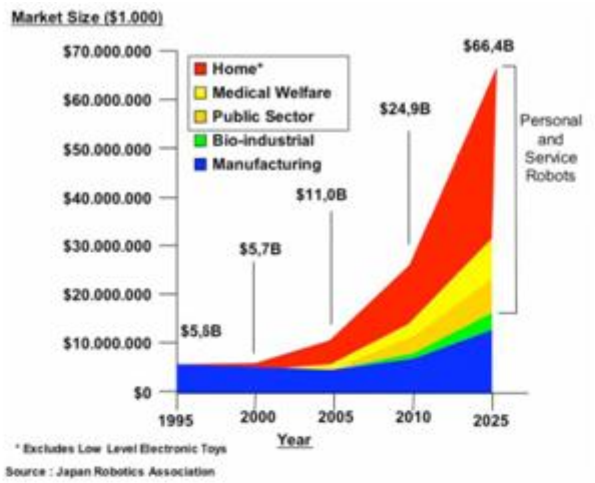


Figure 1.1: Expected market size of Robots[iv]

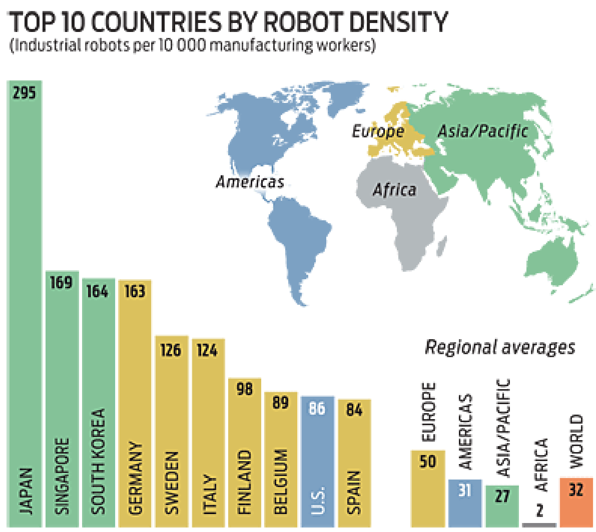


Figure 1.2: Spread of industrial robots[v]

1.2 Objective and goal

In 2004, the Dutch government established ICTRegie to stimulate the innovative powers of the Netherlands by means of ICT research. ICTRegie developed 15 ICT Innovation Platforms (IIPs). IIP RoboNED is one of them. In this platform researchers, entrepreneurs, but also OEMs and end-users are united. One of the main activities is the development of a strategic agenda for the robotic field in the Netherlands.

Since April 2010 in the Netherlands, robotics activities are coordinated by IIP RoboNED. This Dutch Robotics Platform aims to stimulate the synergy between the robotics fields and to formulate a focus.

The goal of RoboNED is threefold:

- Bring the various fields and disciplines involved in robotics together,
- stimulate the innovation-ecosystem in the Netherlands by unifying stakeholders from research, education, industry and society,
- and stimulate the social acceptance of robotics in the Netherlands.

1.3 Method

Academic and industrial partners are cooperating in RoboNED to create a national strategic agenda. This strategic agenda consists of two parts. Part 1, this report, presents the Dutch robotic analysis and part 2 will present the roadmap on technology, education, and ethical, legal and social-issues. Part 2 will also contain a market analysis.

1.3.1 Clustering

Robots can be used in different application fields. To get an overview of these application fields a clustering is made, as shown in Figure 1.3. Each cluster reflects a separate field with a specific ecosystem and market, based on the task of the robot. This clustering is designed for the Dutch situation, based on the American[vi] en European[vii] roadmaps.

The grey (light) colored fields in Figure 1.3 are marked as high potential robotic fields. On these fields, clusters of RoboNED are active. The fields 'Maintenance & Inspection', 'Defense, Security & Safety' and 'Logistics', all coming from the same higher level field 'Professional Services', are incorporated in one cluster. The RoboNED strategic agenda is dealing with six clusters namely, Agro&Food, Care, Cure, Domestic Services, Manufacturing and Professional Services.

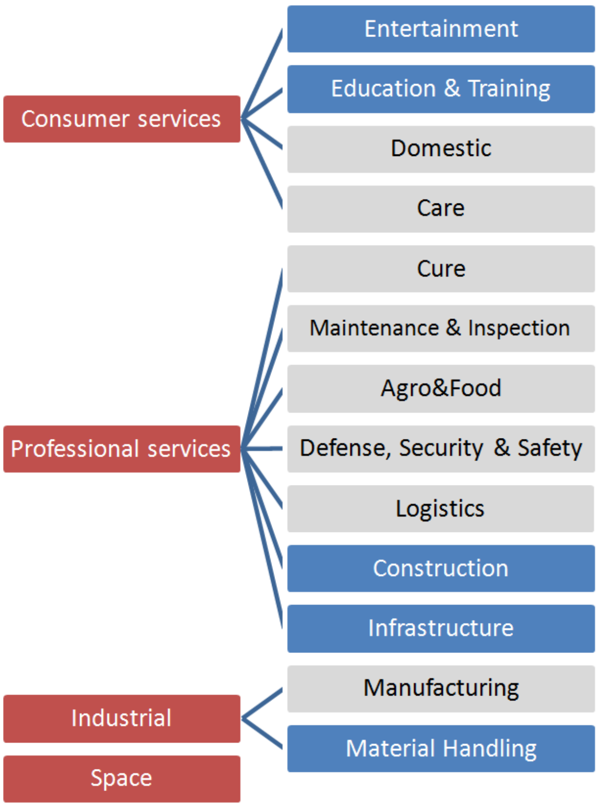


Figure 1.3: Overview of the Dutch Robotics.

1.3.2 SWOT-analysis

In this report we discuss the six fields, Agro&Food, Care, Cure, Domestic Services, Manufacturing and Professional Services by performing a SWOT-analysis. The six fields are analyzed on the internal and external situation on four different aspects: Social-Cultural, Technological, Political-Legal, and Economical. After confronting the SWOT-elements of the internal analysis (Strengths and Weaknesses) with the SWOT-elements of the external analysis (Opportunities and Threats), making use of a confrontation matrix (see Figure 1.4), we can conclude the analysis with recommendations to improve the development of the specific robotic field.

		External	
		Opportunities	Threats
Internal	Strength	**Offensive Quadrant**: How can we leverage strengths to benefit from opportunities?	**Defensive Quadrant**: How can we use strengths to minimize the impact of threats?
	Weaknesses	**Reinforcing Quadrant:** How can we ensure weaknesses will not stop us from opportunities?	**Retreating/Turn around Quadrant:** How can we fix weaknesses that can make threats have a real impact?

Figure 1.4: Confrontation matrix

The information presented here is based on 'RoboNED seminar 3' where the clusters presented the strengths and weaknesses of the particular robotic field. Strengths and weaknesses are referring to the internal situation of the cluster, meaning the factors that form the cluster like the subfields, the stakeholders involved, the innovation power, the investment budget and the (societal) problem that the cluster is solving. The participants of the seminar made an inventory of the opportunities and threats of the cluster. Opportunities and threats are referring to the external situation of the cluster, meaning the factors from outside that influence the cluster like: economical situation of the Netherlands, the attitude of the society, governmental decisions and the demographic situation. Finally, the participants were asked to assign their most important opportunity and threat. The data from 'RoboNED seminar 3' is processed and the results are given in the SWOT-tables in the cluster chapters.

1.4 Outline

This report consists of six cluster chapters all having the same structure, starting with an introduction on the cluster itself. Next, the SWOT analysis is presented, on which a confrontation analysis is performed. From these results in the last section recommendations and conclusions are given. The last chapter presents a meta-analysis on the results of the clusters.

2 Agro and Food

2.1 Introduction

The field of Agro and Food robots is defined as the category of robots performing tasks in agricultural environments and the processing of agricultural products.

The cluster Agro and Food is considered to include, among others, the following subfields:

- Livestock farming (e.g. milking robots, cleaning);
- Arable farming (e.g. autonomous vehicles, weed control);
- Protected cultivation (e.g. crop maintenance, harvesting, packing);
- Orchards (e.g. harvesting and spraying);
- Plant propagation, ornamentals (e.g. pruning);
- Post-harvest processing (e.g. grading, packing);
- Meat processing (e.g. cutting, packing).

The Netherlands are up-front in agriculture in terms of productivity and efficiency with main emphasis on protected cultivation (horticulture) and livestock farming.

Main suppliers include for instance Lely, Aris, Jentjens, Lacquey, CCM, Priva, Kverneland, SBG Innovatie, Tyker Technology, WPS, SAC Nederland, Methore, Moba, Robertpack, HAWE, Aweta, Quest, Havatec.

The Netherlands houses some main suppliers on a worldwide level in the field of livestock farming and protected cultivation. In arable farming, main suppliers are less well represented in the Netherlands. Though being world players, these companies are still quite small, supply relatively small markets and therefore only have little room for investment. The past 5 to 10 years have shown the advent of some (very) small high-tech development companies.



1 2 3

Figure 2.1: Examples of Agro and Food Robots. 1) Cucumber Harvesting Robot (Wageningen UR/Greenvision), 2) Lely Astronaut Milking Robot and 3) Weed Robot (Wageningen UR)

2.2 SWOT-Analysis

2.2.1 Social-Cultural Aspects

In horticulture important drivers for agro-robotics are increasing labor costs, the limited availability of sufficiently trained labor and the poor image of the sector due to employment of (illegal) foreign workers who are not familiar with Dutch labor regulations. Agro-robotics might also support quality improvement of the harvested product. In livestock farming agro-robotics might offer the farmer more freedom. Additionally, robotics can take over heavy, dirty and unhealthy work, will save labor and thus reduce costs. The same holds for arable farming.

In general, in agriculture, agro-robotics will replace heavy, dirty and unhealthy work and by replacing human labor will support improvement of the economy and efficiency of production, will support more efficient use of other resources and reduction of emissions like nutrient and (crop protection) chemicals to the environment.

As a potential negative emotion exists in society with respect to the intensive deployment of technology in food production, this needs pro-active attention. It might be turned into an advantage by focusing on positive effects of robots on food safety, animal health, and the negative image associated with illegal labor.

2.2.2 Technological Aspects

Despite more than three decades of intensive research, there exist only a few commercially available robotic systems. Success of robots in agriculture depends on the amount of structure of the product to be handled and the working environment of the robot. In horticulture, robots are currently available for producing cuttings, planting in trays, plant protection, sorting and packing. No commercial examples are known for harvesting and crop maintenance. In livestock farming the most famous and successful example is the milking robot. New products include automated feeding, manure removal, cleaning of sheds, and automatic fencing on the field. As safety is a major issue, in arable farming examples of robotic systems are very limited.

There is a lot of innovative research in agro-robotics in the Netherlands including examples like leaf picking of tomatoes (Tomation), sweet pepper harvesting (Crops), rose harvesting, sweet pepper packing, gripping of soft products (Lacquey), autonomous weed control (Robot Ruud), field robots, master slave operation of farm machines (Hubrina), snack packing.

There is not much cooperation or cross-fertilization between these innovation projects, because of IP reasons and maybe relatively small markets. This is a potential weakness as it may lead to inefficient use resources and potentially reinventing the wheel in each project.

Robots in agriculture need to fulfill two main functions: mobility on the farm and manipulation of objects. Robotics is defined as the intelligent transformation of sensing into mechanical action. Research is generally focused on sensing, mobility (e.g. autonomous vehicles), manipulation and end-effectors. However, not much attention is paid to:

1) intelligence, navigation and manipulation in unstructured environments,
2) safety for humans, animals and the crop,
3) the fact that the machine has to work in a hostile environment in terms of dust, dirt, rain, light, temperature variations etc.

As the essential functions needed in agricultural are a limited subset of human capabilities, an agricultural need not resemble a human being.

2.2.3 Political-Legal Aspects

Until recently, there was not much political support for development of agro-robotics, both in practice and research. However, recently this has changed and robotics is considered to give a contribution to the sustainability of the agricultural sector. Yet, this is not yet translated into funding for research and development of agro-robotics. At EU level, robotics is gaining more and more attention and funds are becoming available.

In general the farmers and suppliers have a strong positive and innovative attitude and are open to robotics, but due to the small size of the players involved there is hardly ever enough capital available to take the risk of developing and implementing high-tech robotic systems.

The Netherlands are up front in agriculture worldwide; farmers, as well as suppliers and research.

With a contribution of 10% to the gross national product, the agro-food chain is amongst the main contributors to the Dutch economy.

Key legal aspects include safety and liability. Also issues with respect to IP in some cases hamper development of agro-robotics.

2.2.4 Economical Aspects

In many cases, in agriculture, robots are economically feasible. Since people need food and flowers and due to the fact that less labor will be available in the future, potentially there is a huge market in the Netherlands, Europe and worldwide.

The agricultural domain is divided into a large number of small and specialised markets. The automated milking systems market is one of these specialized markets in which the Dutch Company Lely is market leader. Due to their small size, the room for investment by individual farmers and also suppliers is (very) limited.

The risk for both farmers (growers) and suppliers to introduce new robot systems is in general too high to handle. Sharing knowledge and intensive collaboration might mitigate this problem. Open innovation might be a solution.

2.2.5 SWOT- table

In Table 2.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 2.1: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	**Weaknesses**
Robotics solves problems of labor (availability, image) Netherlands up front in agro; both farmers and suppliers Robots are economically feasible	Technology (available but) does not fit enough for agriculture (unstructured, harsh environment) Not much cooperation and reinventing the wheel (due to IP issues) Diverse application fields, small companies, small markets, not much budget for investment
Opportunities	**Threats**
Make use, share and further develop technology Laws and rules on food safety, hygiene and labor Large demand and need	Acceptance by the consumer Too little cooperation on technology (IP-rights) Too few investment possibilities

2.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

2.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

In the Netherlands the agro-food chain forms a substantial part of the gross national product and has a good international position. We can keep this position by solving the lack of labor and increasing the productivity by making use of robots that are suitable for agricultural applications. These robots can be developed by using common technologies already used in other application fields and by working together with robot application fields on new technologies.

2.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

Due to the large divided agricultural domain, and therefore small markets, there is not much budget for investments. The individual growers and suppliers are not able to invest in robots. Though robots are economically feasible, growers and suppliers should join forces. Together they can financially invest in robots. The financial investments for the growers and suppliers should be kept low. A possibility to keep the financial investment low is to develop an agro robot platform adaptable for every individual grower or supplier.

2.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

The existing technology is not suitable for the agricultural environment which is unstructured and harsh. Other application fields are also working on developing robots that are able to work outside conditioned environment of the factory. E.g. a soft and safe gripper able to deal with humans in the environment has a lot of comparison with the gripper needed to grasp a tomato. Joining efforts on the level of technology will accelerate the developments.

2.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

It is very important to work together to be able to profit from robot technology. There are two levels on which should be joined efforts, on the development of the technology and on the financial investments necessary. When developing technology there are also two levels on which should be worked together. When developing new technology the other application clusters are very important partners. When making available technology suitable for the agricultural environments and circumstances it is important to work together within the cluster itself.

2.4 Conclusions and Recommendations

The Agro and Food cluster is considered to be potentially a very important application area for robotic systems not only in the Netherlands but worldwide. The development and use of robots will not only enlarge the export by international collaboration in terms of products but also in knowledge and finance. Agro-robotics will support a sustainable development of agricultural production by solving challenges like shortage of labor, growing production costs, competition on the international market, poor labor conditions, poor labor image, food safety and product quality and efficient use of resource and reduction of emissions of chemicals to the environment.

The Netherlands are up-front in agriculture in terms of productivity and efficiency with main emphasis on protected cultivation (horticulture) and livestock farming. In general farmers and suppliers have a strong positive and innovative attitude and are open to robotics. Despite more than three decades of intensive research, there exist only a few commercially available robotic systems. Success of robots in agriculture still depends to a large extent on the amount of structure of the product and the working environment. There is a lot of innovative research in agro-robotics in the Netherlands.

More cross-fertilization between innovative projects, companies and research institutes might amplify progress in agro-robotics. Limited support by government and funding organizations for research and development and innovation in this field, is still a major problem. However, recently robotics gains more and more attention of these organizations.

It will be wise to focus more research effort and knowledge development on dealing with operations in complex and unstructured environments as this seems to be a key issue for successful introduction of robotics in agro and food. From a technical and legal point of view, safety is an important issue as well.

3 Care

3.1 Introduction

Care robotics is defined as robots performing tasks in a (long term) care environment like a nursing home, a home for the elderly, a therapy practice or, if the patient can still live in his/her own house, at home.
Activities in the 'robotics for health' domain is distributed by RoboNED among two clusters: Cure and Care. The subfield 'Therapeutical' is partly included in 'Cure', partly in 'Care'.

Subfields within this cluster are, among others:
Care robotics

- assistive robots for monitoring at home
- assistive robots for personal use and household tasks (welfare)
- assistive robots for nursing/caring tasks
- paramedic tasks
- social activation robots (dementia and cognitive disabilities)

Therapy/Rehabilitation robotics

- therapy/rehabilitation
- prostheses/ortheses
- cognitive therapy.

In the Netherlands researchers are active on all of the abovementioned subfields of care and rehabilitation robotics, but especially on robots for monitoring and household tasks and on rehabilitation.

Presently, there are no Dutch suppliers in this specific field, but several companies could join this field. There are, however, several Dutch Original Equipment Manufacturers (OEMs) in the domain: e.g. DEMCON, Focal Meditech, Assistive Innovations, Intespring and Exact Dynamics, Motek Medical, etc.

There are numerous customers (defined as parties with influence on the buying decision):

- Health Insurance companies,
- (local) Government (WMO: Law for Societal Support),
- Management of nursing homes en other (residential and home) care institutions,
- Medical professions,
- Paramedic professions,
- Nursing and caring professions,
- Patients/informal caregivers and patient organizations.

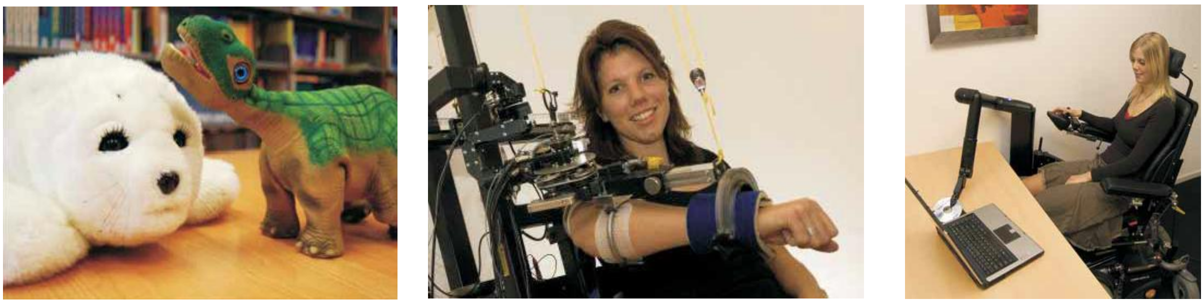


Figure 3.1: Examples of Care Robots. 1) Social robots: PARO (seal) and PLEO (dinosaur), 2) Rehabilitation Robot Dampace (UTwente) and 3) iARM (Assistive Innovations).

3.2 SWOT-Analysis

3.2.1 Social-Cultural Aspects

The most important driver is the ageing of society. There is a strong correlation between age and the need for long term care. Ageing has two demographic causes. People are becoming older due to improved prevention and healthcare. Therefore the absolute number of elderly people increases. This will be a permanent improvement. The other reason is a high birth rate in a certain period of time (post war baby boom). This is a phenomenon with a transient character. Several decennia after the return to a normal birth rate the relative number of elderly people increases for about the same period of time as the period of the baby boom.
Another driver is the continuing growth of the importance of Quality of Life, autonomy and participation of elderly (and people with chronic illnesses and disabilities) as compared to "simple" nursing.

Also very important in a number of countries like the Netherlands is the imminent shortage of health personnel in a tight overall labor market.

The relative shortage of care personnel is partly due to the labor conditions which compare unfavourable with other sectors.

Awareness and acceptance are key words to understand the attitudes of all important stakeholders: patients, health professionals, health managers, health insurers and health authorities. The stakeholders that are responsible for the financing of the R&D programmes must feel convinced that the benefits of robotics are larger than the investments in the development and the costs of operation. The patients and health professionals (and informal caregivers) have to accept the robots in their direct environment and must be willing and able to use them effectively and easily.

3.2.2 Technological Aspects

In the field of robotics a large number of existing and emergent scientific and technological disciplines are working together: ICT, materials science, construction technology, nanotechnology, cognitive and neurosciences etc. The technologies used for robot systems in various domains overlap to a large extent. It is important to master the complex multidisciplinary and multi-actor development trajectories to reap the fruits of these large potential benefits.

In care robotics, many of the most important technologies focus on the safe and clear cooperation with people. In this context, the technologies that currently get the most attentions are:

- intention estimation,
- reliable sensors,
- safe navigation and manipulation,
- shared control,
- light weight materials and constructions,
- human robot interaction.

3.2.3 Political-Legal Aspects

In most European countries a number of general and specific programs are in operation to stimulate emergent fields like robotics. However, legal problems occur regularly in the health technology sector. Admission procedures are mostly geared to make decisions on the basis of effectivity and cost efficiency of interventions and do not take into account the problems of evaluation of interventions in the stage of development and the higher costs directly after first introduction.

Special attention will be needed to formulate new policies and legislation to accommodate the new needs for education and to take into account ethical and social aspects.

3.2.4 Economical Aspects

Potentially, the market of robotics for health and for care in particular is immense. A large part of this market can be financed with public money (the health insurance system and local government) but a normal consumer market ("comfort products" for the elderly) can also develop. However, there is still much uncertainty in the market about the costs and risks of the development of new systems and about the costs in relation to the benefits of the new robot systems once they will be in operation. It is also not yet clear who will pay for the investments and who will finally benefit of these lengthy and complex innovation trajectories.

3.2.5 SWOT-table

In Table 3.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 3.2: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	**Weaknesses**
Good cooperation climate research-companies Companies and networks in regions Good international contacts Many sound ideas for research	Many subjects, not much focus Technological driven Long term care not technology-minded Not many 'real' robot companies/production chains
Opportunities	**Threats**
Improvement of Labor conditions, Labor capacity and quality of life Utilizing existing technology Market potential due to ageing	Acceptance by Patient and Caregiver Political, legal and societal awareness and acceptance Costs and financial risks

3.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention.

3.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

- Execute a needs assessment by selecting from existing project proposals the ones that fulfil the most needs. Develop proposals for important unmet needs.
- Develop special idea generation and selection procedures for proposals for improving labor productivity and labor circumstances.
- Do the same for proposals for improving quality of life by staying longer at home and by self management.
- Connect the best topics to combinations of research groups, companies and care institutions already participating in the cluster Care (and other clusters of RoboNed).

3.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

- Special attention in the design and selection criteria for acceptance by the patient: attention for topics that are useful from the patients' point of view and attention for human factors and emotional aspects.
- Lobbying in the direction of the financers about the importance of this field: urgent social problems will be solved and real chances will develop for Dutch industry.
- Legislation: develop ways of legislation that take into account the problems of innovation: temporary approval of experimental interventions and allowing temporarily for higher costs.
- Develop in the direction of politics and society awareness about the urgency of the problems in the care sector and a well-balanced image of the significance of robotics for solving these problems.
- The acceptance by professionals and other stakeholders in the care sector can be improved by involving them closely in the formulation of innovation programmes and the implementation of the results.

3.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

- Look careful to the availability of Dutch companies as part of robot production chains; decide carefully whether it is prudent to develop companies in the Netherlands for the missing parts or whether it is better to cooperate with foreign companies.
- Too much technology driven? This weakness will disappear as side product of the approach in the offensive quadrant.
- The same goes for the lack of technology mindedness in the care sector: this will disappear by involving the sector in the innovation programmes (defensive quadrant).
- If objective selection criteria are developed in close collaboration with stakeholders, the program will automatically get more focus and will become more concrete and therefore more interesting for stakeholders.

3.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

- Wait with topics which are disliked most by patients and/or professionals.
- Start with spending the available investment money in a limited number of promising topics to create critical mass and create visible success in the short term.

3.4 Conclusions and Recommendations

The care domain is potentially a very important application area for robotic systems. There are several urgent societal problems for which robotics will be an important and perhaps the only solution. One set of drivers is related to the ageing problem: more elderly and chronically ill people with growing demands for quality of life, autonomy, participation, living longer at home etc. The other important set of drivers is related to the labor market: imminent shortages especially of the caring and nursing professions and labor conditions which compare unfavorably with other sectors of the labor market.

The starting situation is also good. There are many good ideas to follow up. Much of the necessary scientific knowledge and technology is available. Partly this knowledge can be obtained from the other clusters in RoboNED, and a certain amount is already available in current partnerships of researchers, companies and care institutions in the cluster Care of RoboNED.

However, more is necessary to arrive at the desired situation that a good number of applications have reached the stage of robotics systems that are part of regular care provisions, reimbursed by the normal insurance arrangements and used by the average patient, informal caregiver or health professional. More experience has to be gained on how to proceed efficiently through all the stages, with all the stakeholders involved in the right time and in the right way. More extensive and sometimes new innovation networks of research groups, (chains of) companies and care institutions will have to be forged. Financing these complex development trajectories and guiding the resulting technologies through the admission, reimbursement and purchase system will require much attention.

For this reason it will be wise to focus in the beginning on a few applications which are already promising in the near future and develop them in close collaboration with patients and professionals. Awareness activities and attention for ethical and legal aspects are essential. In this way also the chance that the new applications will be accepted are maximized. In the meantime investors and politics will have to be convinced that this sector is worthy of their generous support. In this way the route will be paved to a much larger amount of useful robot applications in care in the longer term.

4 Cure

4.1 Introduction

The field of cure robots is defined as the category of robots performing tasks in general and academic hospitals and rehabilitation hospitals. The clusters Care (previous chapter) and Cure together enclose the activities in the 'robotics for health' domain.

The subfields that can be distinguished within these work fields are, among others:

Robotics for medical interventions

- robot assisted micro surgery (e.g. eye surgery);
- robotized surgery assistance (e.g. systems which provide surgeons or nurses with 'extra arms' to hold or steer for example a camera);
- robotized precision surgery (e.g. orthopeadic surgery based on CT-scan data 3D);
- robotized minimal invasive surgery (e.g. cardiovascular, oncology, orthopedics);
- robotic percutaneous interventions (e.g. endovascular interventions, needle interventions);
- remote surgery.

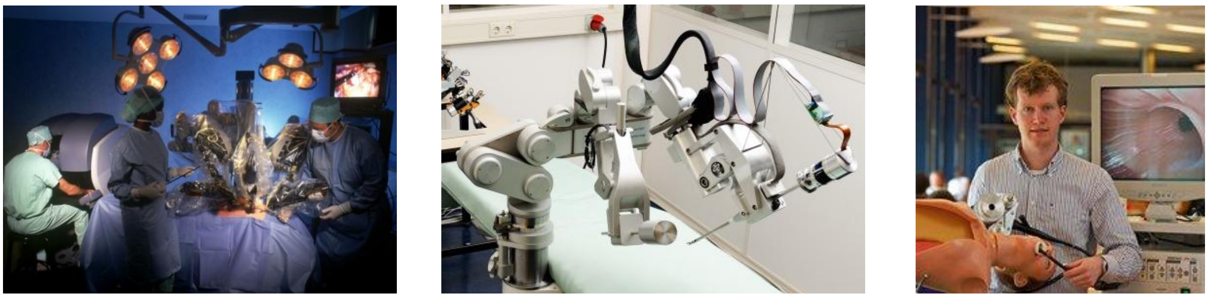
Robotics for medical diagnostics/training robotics

- neurophysiology/human motor control;
- therapy/rehabilitation/prostheses/ortheses.

In the Netherlands researchers are active on all of the abovementioned subfields of cure.

The stakeholders which belong to this cluster are:

- Original Equipment Manufacturers (OEMs)/ multinationals (e.g. Philips Healthcare, Maastricht Instruments, Matteo BVBA, De Koningh Medical Systems, Xivent Medical, Nucletron, DORC surgical, Siemens Medical);
- (Academic) Hospitals;
- medical Specialists;
- patient groups;
- healthcare insurance companies;
- government.



1 2 3

Figure 4.1: Examples of Cure Robots. 1) Da Vinci Surgical System (Intuitive Surgical), 2) Sofie Surgical Robot (TU/e) and 3) Automated Steering for Flexible Endsocopes (UTwente).

4.2 SWOT-Analysis

4.2.1 Social-Cultural Aspects

The graying population is an important social-cultural issue in relation to cure robotics: aging increases the risk of related healthcare problems. The main fields of these problems are cardiovascular, oncology, diabetes, and orthopeadic. In addition to this increased greying population there is an increasing lack of healthcare professionals to provide the care needed. The question is: can robotic technology support this lack of healthcare professionals needed, and can these technological innovations increase the quality of cure?

The improvement in quality of cure plays an important role. Robotised surgery will facilitate new types of intervention (e.g. areas of human body that are difficult to access), higher precision, better durability, better repeatability automation, and reduction of patient trauma. With respect to rehabilitation robotics the increased training intensity and objectivity which can be provided by Robotised Rehabilitation therapy will also result in better quality of cure.

Furthermore, the improvement of diagnostics is an important social-cultural aspect. An earlier and more accurate diagnosis will favor medical treatment.

4.2.2 Technological Aspects

Specific applications that are needed and that are being developed at this moment are:

- navigation and planning based on imaging (e.g. insight in medical interventions);
- modeling (e.g. tissue properties, instrument-tissue interaction, human body models).

From a more general scope, this involves the next technologies:

- actuation (e.g. MRI compatible, impedance control);
- real-time communication;
- human-machine interface and ergonomics;
- end effectors (e.g. grippers for biopsies and interventions);
- control;
- sensors, sensing & perception (e.g haptics).

Different research projects involve the development of technologies for cure robotics, a number of examples are listed below:

- Remote Robotics (TU/e, TUDelft, UTwente, CCM, Frencken, KMWE, Philips Innovation Services, TNO Industrie, Opteq, Fontys);
- Eye RHAS (TU/e, AMC, TNO);
- PITON (DEAM, Technobis, TU Delft, TU/e, TNO Science and Industry, Hemolab);
- SOFIE (TU/e, STW);
- TELEFLEX (UT, DEMCON, Meander, UMCG);
- NeuroSIPE (Delft, Twente, LUMC, VU, VUmc, AMC, ErasmusMC);
- MIRIAM (UTwente, Radboud University Nijmegen Medical Center, XiiVent Medical, Demcon, Siemens);
- ARTUS (Medical Field Lab, UMCU, TU Delft. Virtual Proteins, HemoLab, D&L Graphics, GBO);
- MIAS ATD (UTwente, Roessingh R&D, DEMCON, Use-Lab, Tic Medizin);
- VirtuRob (UTwente, Roessingh R&D, SMK research, Re-lion, Baat Medical).

4.2.3 Political-Legal Aspects

Because the implementation of new technologies requires additional competences, education plays an important role in the application of cure robotics. In the technological domain this includes the education possibilities on the level of MBO, HBO and WO and the education of medical personnel. Good opportunities are also the academic study Technical Medicine (UTwente) and the specialization of nurse practitioners for nurses.

Politics has a large influence through financing, regulations and standards. Research and development in cure robotics is mainly financed by the government. On medical devices several regulations and standards are developed to guarantee the safety of the devices.

4.2.4 Economical Aspects

A large part of the market of robotics for health can be financed with public money (the health insurance system). However, there is still much uncertainty in the market about the costs and risks of the development of new systems and about the costs in relation to the benefits of the new robot systems once they will be in operation. It is also not yet clear who will pay for the investments and who will benefit of these lengthy and complex innovation trajectories.

On the other hand, in medical applications, the market of robotic surgical systems is set to experience rapid growth worldwide, as shown in Figure 1.1. Markets valued at $ 626.5 M in 2007 are forecast to reach $ 14 B by 2014 (Wintergreen research). Thus, potentially the market of robotics for health is immense.

4.2.5 SWOT-table

In Table 4.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 4.3: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	**Weaknesses**
Acceptation of robots is growing Many sound research projects Rapid growth of the market	At present: large investment increases surgery costs
Opportunities	**Threats**
Robots can help solve the problem of the ageing society Improvement of the quality of cure Use, share and develop technology	Fragmented development and investments Safety and Liability Cost cuttings and financing model by government

4.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

4.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

The hospitals which offer robotic therapy and surgery attract more patients. These patients show that there is a growing interest to be treated by means of robotics. Patients acknowledge the improvement of healthcare by robots. This growing interest of patients together with the improvement of healthcare by robots can stimulate hospitals to invest in robots. The high pressure on the healthcare system due to the ageing population can in this way be illuminated. It makes it possible to treat more patients at the same time.

4.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

The many excellent research projects being executed in this field, which is a strength of this cluster, should focus on the collaboration with both companies and care professionals. In this way the fragmentation in the development of cure robotics can be prevented. Till now the academic development stops when the prototype is finished. By earlier involvement of care professionals and companies the knowledge can be transferred and will eventually result in a medical device that can be used in medical practice.

4.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

Robotics is applicable in many fields, while the technology is universal. Investments in the development of technology can be shared over the application fields by working together on technology level. This is an opportunity to reduce the high investment costs for healthcare.

4.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

Cost cuttings by the government will decrease the investment budget in cure robotics. The budget that is left should be invested in a very efficient way to prevent the development to slow down. An adequate finance model can help to prevent this threat to have a real impact.

4.4 Conclusions and Recommendations

Robotic systems in the cure cluster could play an important role in urgent social-cultural problems: the demand for cure is growing because of the fast aging of population. It is evident that these elderly people experience more health related problems. In addition there is an increasing shortage of healthcare professionals to provide the required quality of cure. Robotics have high potentials to solve these problems.

In the scope of the problems related to aging of the population, there are many opportunities for robotics that are used for surgery, diagnostics and rehabilitation. Besides, these robotics will also contribute to quality improvement of healthcare.

Another important issue in healthcare are the rising costs of our healthcare system. On the long term, robotics have the potential to reduce these healthcare costs. However, financial investment in development, education and application of cure robotics is necessary on short term.

Currently, a lot of research and development is done in the field of cure robotics. High opportunities can be found in the cooperation with other fields of application, in which knowledge and technologies are shared and used in a broad range of applications. This has also economical advantages. However, most development trajectories have an academic nature at this moment, due to the experimental character. More cooperation with companies is important to transfer new technologies into the market.

Safety and liability are also important issues of robotics in healthcare. Opportunities can be found in the increase of awareness of patients in the state of art of cure robotics. When patients are more aware of the advantages and the current applications of robotics in healthcare, these robotics become more accepted.

5 Domestic Services

5.1 Introduction

The field of domestic service robots is defined as the category of robots performing tasks in domestic environments. There is some overlap between the clusters ‘Domestic services’ and ‘Care’. RoboNED chose to draw the line between both clusters by the market the product is made for. Domestic service robots provide the execution of a certain task for a consumer who can make a purchase decision independently. Care robots are made for the Health Care market, which is characterized by a financing by insurance companies. Also, there is a strong link between domestic and professional service robots: applications are similar and robots will be strongly related. Technologies and research can easily be interchanged between both clusters, applications in one of them can easily be translated to the other one.

This field is very broad and includes among others:

- cleaning (vacuum cleaning, pool cleaning, gutter cleaning,…),
- lawn mowing,
- telepresence robots.

In figure 5.1 examples are given of domestic service robots.

The focus in the Netherlands within this cluster is on domotics and vacuum cleaning robots. Domotics[viii] is the residential extension of "building automation", it is automation of the home, housework or household activity. Domotics is provided by several companies in the Netherlands, for example Entron, Honeywell and NIKO. In the field of vacuum cleaning robots, Philips is the main Dutch (and European) Original Equipment Manufacturer (OEM), competition is mainly from other continents, like North America (iRobot) and Asia (Samsung, LG).

Everyone is a potential consumer of domestic robots, which assigns an ambassador function to the domestic robots. Through the domestic robots, people get used to robots that interact with them in their own homes.

1 2 3

Figure 5.1: Examples of Domestic Service Robots. 1) Philips ‘HomeRun’, vacuum cleaning robot, 2) Husqvarna Lawn Mowing Robot and 3) Gostai Telepresence Robot

5.2 SWOT-Analysis

5.2.1 Social-Cultural Aspects

In the current society, people tend to have faster and busier lives than ever. Less and less time seems to be available to spend with family and friends. By freeing up time currently spent on household chores, more quality time can be created.

Especially in families where both parents are working, taking over part of the household by robots makes life considerably more comfortable. This way, it is achievable that both partners build a career, instead of having one of them stay home to perform household chores. Traditionally, women tended to stay home for these reasons, so especially this part of society can benefit a lot from robotic household technologies.

In addition to the working population, also the growing generation of elderly can benefit from domestic service robots. Domestic robots can take over some of the most demanding (in power and frequency) tasks, such as vacuum cleaning and lawn mowing, and thus decrease dependency of external parties. Next to that, the category of telepresence robots can follow and monitor solitary elderly, provide companionship and alert the right channels in case of an emergency.

5.2.2 Technological Aspects

There are several projects in which technology for domestic service robots are developed. For detailed information on the projects see the Online RoboNED Database[ix] and the Dutch Robotics Inventory[x]. Four of the most important technical challenges within this cluster are mentioned below:

One of the main challenges within this cluster is navigation in unknown and undefined environments. These environments are typically quite complex, with a lot of both static and dynamic objects. Solutions to this navigation challenge are proposed in academic studies, but working towards a robust and affordable solution still asks for high investments by companies, both in time and money. Interesting about this challenge is that it’s not only a challenge within the domestic service cluster, but almost all other clusters encounter similar problems.

Another challenge within the domestic service cluster is safety and also this one is common to most other clusters. Driving around in unknown environments, encountering unknown objects and people (from babies till elderly) poses a lot of requirements on the safety of the robots. Factually, these robots should be intrinsically safe, not being able to damage people or objects under any circumstances. With light weighted and relatively slow moving robots, intrinsic safety is mostly achievable, but the more complex and, heavy robots become, the more dangerous it might get, if no additional measures have been taken. Research is needed to find robust and cost efficient intrinsically safe solutions.

A third challenge is user interaction with the robot: the way the user –mostly not educated in robotic interaction- gives commands to and receives feedback from the robot. The user should be able to interact with the robot in a natural way to get the threshold in user-robot interaction as low as possible. It’s clear that nowadays, a lot of people don’t know how to interact with robots, and most robots don’t know how to pleasantly interact with humans. Again, this is a topic common to a lot of clusters, although, in some of them, robot operators are educated for this specific task.

The fourth challenge, and at the same time opportunity, in domestic service robots, is user acceptance. Do users accept robots to intrude in their personal or professional lives? In this respect, domestic service robots can play an important role, at the time being simple and low-intrusive robots (i.e. vacuum cleaner robots can be limited in autonomy by closing a door or placing a simple beam on the floor), they can pave the way for their more complex and more autonomous offspring. Domestic service robots have an ambassador function in the acceptance of future domestic service robots, but also in the acceptance of robots in most other clusters.

5.2.3 Political-Legal Aspects

The current political influence within this cluster is focused on providing research grants, mainly on fundamental research.

Despite some research on the future developments of this type of robots, more action has to be taken urgently to ensure that these developments are commercialized. In competitive countries, either an industry based government policy is adopted (Asia), or spin offs of defens research support the industrial development (USA). This is clearly visible in the amount of companies really developing robotic technologies and putting products on the market.

On the legal aspects, it's clear that legislation is outrun by technology. Questions about responsibility in case of accidents, regulation about safety,… all lag behind the state of the art technology.

5.2.4 Economical Aspects

Figure 5.2 shows that the market in WE doubled in size in 2009 and in 2010 growing faster than forecasted. Clearly, the market is emerging and growing very fast.

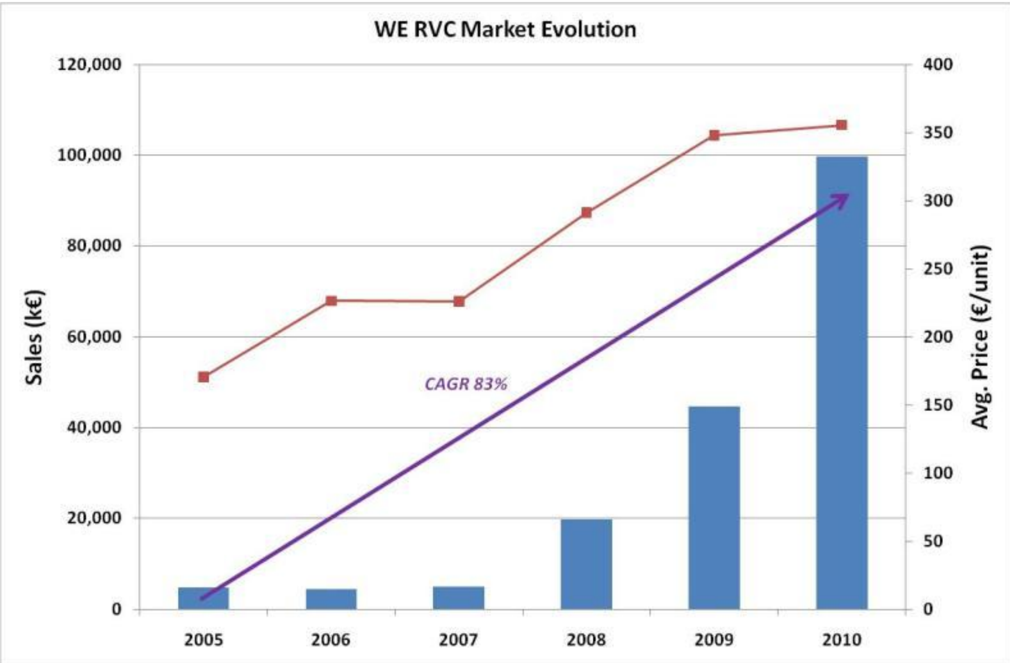


Figure 5.2: Western European Robotic Vacuum Cleaner Market Evolution[xi]. The blue bars give the sales in K€, the red line gives the average price per unit. The purple arrow gives the compound annual growth rate.

Although the current (worldwide) market size of domestic service robots is still relatively small (10 million units shipped in 2010), the cluster represents a very fast growing market with a large potential (expected to have 35.1 million units shipped in 2017 (ABI Research[xii]). This growth represents a CAGR of almost 20 % over a 7 year period.

According to the aforementioned forecast, the majority of these shipments will be task and entertainment robots of less than 500 $ and performing mostly a single function.

5.2.5 SWOT-table

In Table 5.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 5.4: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	Weaknesses
Common technologies with several applications. Development of technologies driven by industry Very fast growing and large market. Strong international player available in the Netherlands for commercialization of robot products.	Gap between academic research and commercial product (time and money). High investments in emerging market. Too few companies involved in commercialization.
Opportunities	**Threats**
Improved time efficiency Ambassador function Share/Use Common technologies Market-Potential	Acceptance of robots near humans Various technological challenges to be solved No clarity on laws and rules on safety and liability Other countries are moving fast due to industry based government policies or defense push

5.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

5.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

As a lot of different applications within this cluster, but also outside of the cluster (i.e. professional service robots), need similar technologies, the development of these technologies needs only to be done once to open up a can of possible applications. So, if companies developing applications combine forces in developing common technologies, a strong international position can be achieved.

5.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

The main threat is that the robotics industry in other continents is speeding up the commercialization of robotics through either a governmental industry policy or through spin-offs from the defense industry. In order to speed up commercialization in the Netherlands (and across Europe) it should be stimulated that companies work together on the common technologies. They can commercialize these common technologies in different application fields. Having a strong international player in the Netherlands is a strength that can be utilized. There are already concrete business cases and there is experience in commercialization of robotic products.

5.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

Because of the gap between academia and industry large investments are needed to reach a sufficient maturity level to enter the market. Companies are hesitant to make these large investments in an emerging market which hampers the commercialization of robotic products. This is a threat for the opportunity of building and commercialization of many applications within and outside of the domestic service cluster. Technology and products only become economically feasible when leveraging technology over different applications and joining forces to build the common technologies.

5.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

The gap between the academic community and the industry is hampering the commercialization of robotic products. Because of the gap, high investments are needed for robotic product development to reach a sufficient maturity level for market entry. As companies can’t afford these kinds of investments, companies and academia have to cooperate on the common technologies. This can be achieved by providing seed capital to companies and/or by stimulating projects with a stronger market link.

5.4 Conclusions and Recommendations

On the bright side, the market growth is huge and forecasts expect a CAGR of almost 20 % over the coming 7 years. So, there is a tremendous potential in this market. Also, a lot of research is conducted in this field. So, the fundamentals of the technologies are there.

As human-robot interaction and user acceptance of robots are a major threat across all clusters within the robotics landscape, and the domestic service robots represent at the time being a category of low-intrusive, easy to manipulate robots, the domestic service robots have an ambassador function. As everybody is a potential consumer of this category of products, people can get used to this kind of robots before more complex and intrusive robots appear in their lives.

Two big influences define the climate within this cluster: the market is still very immature and, the technologies are not onto a level they can be swiftly integrated into products. As a result, companies have to make huge investments to develop domestic robot products, in a high risk market. Except for one big international player, Philips, none of the Dutch companies have taken this risk yet.

The gap between the academic community and the industry is hampering the commercialization of robotic products. Because of the gap, high investments are needed for robotic product development to reach a sufficient maturity level for market entry. As the huge gap between academic research and saleable products strongly holds back the development of the Dutch market, this is the main point to tackle. A few solutions can be thought of:

- either academic research should be extended more towards products, taking into account cost price, market demands, robustness, lifetime,…, or
- more investments should be made towards developments companies, to allow them to mature the technologies, without running very high risks, or
- an intermediate institute should take up the step between academic research and product development. As an example, the FMTC (Flanders Mechatronics Technology Centre) performs this task in Flanders on mechatronic level. Possibly this could be part of Brainport Industries (CFT 2.0)

Leveraging of technologies over different applications (within and outside of this cluster) and a government that stimulates closing the gap between academia and industry are crucial to get a leading edge in the robotics market. This will lead to lower needed investment levels, more companies involved in the robotics business, more applications (to leverage technologies over) and a strong position within the international robotics market thereby valorizing the very good academic research in the Netherlands.

6 Manufacturing

6.1 Introduction

The field of manufacturing robots can be defined as the category of robots performing processing and material handling tasks in industry.

Within manufacturing, the market and the applications for industrial automation can, among others, be split into:

- Automotive (e.g. welding, gluing, painting);
- Metal (e.g. welding, gluing, painting);
- Plastics (e.g. gluing, painting);
- Foundries (e.g. pouring, deburring);
- Food & Beverage.

Focus in the Netherlands is on the suppliers of the automotive industries and on the food and beverage market.

The main suppliers belonging to this cluster are:

- Industrial Robot suppliers: ABB, Fanuc, Kuka, Yaskawa, ect…
- Vision suppliers: Aris, Data Vision, Iris Vision, ect…
- Gripper suppliers: Schunk, Destaco, ZVS, ect…
- Process equipment suppliers: Esab, ect…

In general, all required product suppliers are available on the Dutch market. Also the product and application knowledge is available for the main components at the suppliers. Furthermore borders and distances are limited to get the required information from abroad.

In every market segment several system integrators are active for a (number of) specific applications:

- Automotive: VDL Steelweld, AWL, etc…
- Metal: Valk Welding, Manders, Ferdar, etc…
- Plastics: Koot Automation, Ronetic, etc…
- Foundries: Pomac, Exner, ect…
- Food & Beverage: CSi, Rohaco, Dero, RobertPack, etc.…

Customers of this cluster are:

- Automotive: NedCar, DAF, etc…
- Metal: Polynorm, VDL, Aalders, etc…
- Plastics: Promens, Aarts, PipeLife, etc.…
- Foundries: Brabant Alucast, Lovink, MGG, etc..
- Food& Beverage: FrieslandCampina, Heineken, Perfetti, etc..

1 2 3

Figure 6.1: Examples of Manufacturing Robots. 1) Pick and Place Robot (ABB), 2) Gripper (Lavquey B.V.) and 3) Laser Welding Robot (ABB)

6.2 SWOT-Analysis

6.2.1 Social-Cultural Aspects

This cluster manufacturing solves several social issues:

- Improve quality of work for employees;
- Comply with safety rules and improve workplace, health and safety;
- Reduce labor turnover and difficulty of recruiting workers.

Benefits of robots are:

- Robots can do the dirty jobs, they never complain about noise, heat, cold, dust…etc.
- Robots can do the heavy jobs, they never complain about weight, breaks and working hours.
- Robots can do the dangerous jobs, they never feel unsafe in a big machine park.
- Robots are flexible, once the job is finished with another tool, they can do another job.

The attitude of the conventional market regarding robots is still full of prejudice about prices, complexity and flexibility of robot cells. The benefits of robotics are not yet common knowledge.

The attitude of the society regarding this robotic cluster is resistant at older generations. Younger generations accept robots easier.

6.2.2 Technological Aspects

A lot of Dutch research projects are being executed at the moment:

- ESI Falcon: underactuated grasping;
- Robots that learn to move naturally;
- Sharing Control: intelligent guiding systems to assist humans;
- Computation of partial closure grasps;
- Clet project: Closed loop control of laser welding through electronic temperature;
- Vision in Mechatronics and Robotics.

The manufacturing cluster needs the following technologies:

- better batteries and lower energy consumption to have flexibility in production facilities, including lighter material for robot constructions;

- better vision and sensor technique to see products faster and more accurate and to feel how much force is needed to grip or to grind;
- Better gripper technology;
- better communication:
  - between CAD/CAM data and a robot program,
  - between robot and operator to make life more easy and more safe.

Technologies and experience available in manufacturing can be used in other segments. Since industrial robots do have a history of more than 35 years, the motion performance is a proven technology. Also the reliability is high as industrial robots are able to work for 24:7. Furthermore a lot of experience is coming from the Automotive segment, where robots need to be flexible (sensor technology) and multitasking (gripper technology).

6.2.3 Political-Legal Aspects

The main policies of the Dutch government influencing this cluster are:

- Education. The Dutch government can influence the amount of skilled talent with a technical background.
- Investment climate. The Dutch government can influence the investment climate to encourage investments in robotics and to stimulate entrepreneurs to invest in robotics.
- The laws on production safety and workers health. Robots can be a solution in situations where the environment is not safe for humans.

6.2.4 Economical Aspects

An OEM in robotics invests 15%-25% of the profit in innovations in robotics. That is, in comparison to other clusters, a large budget. The total turnover of this market is 1000 industrial robots per year in the Netherlands. This is in comparison with other countries a low turnover. As shown in Figure 6.2 the operational stock of industrial robots is steady[xiii].
Production costs can be decreased by making use of robots. Conventional production processes are prone to human errors. Robotic production results in zero defect production and in this way decreases the production costs.

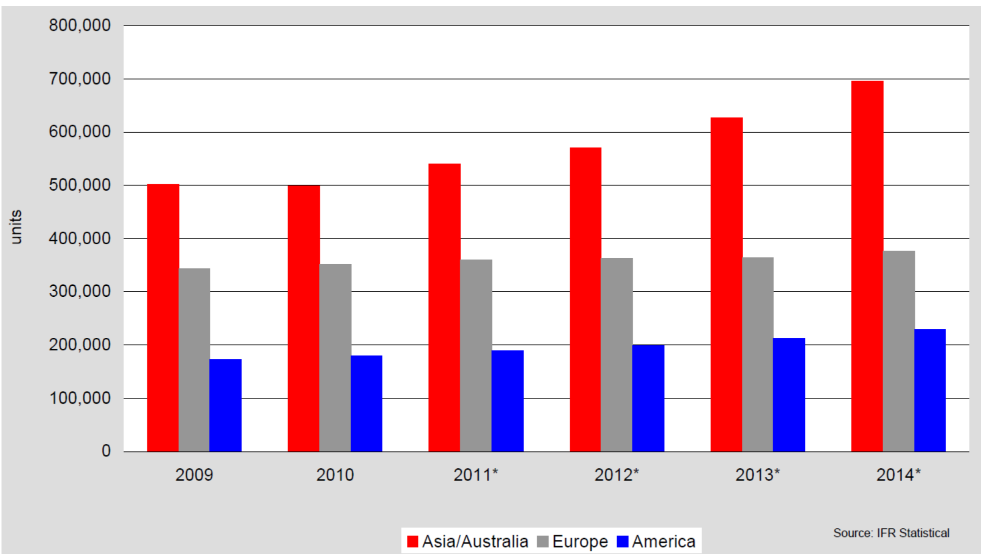


Figure 6.2: Estimated operational stock of industrial robots 2009-2010 and forecast 2011-2014. (World Robotics 2011, IFR Statistical Department[xiii])

6.2.5 SWOT-table

In Table 6.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 6.5: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	Weaknesses
Improves working conditions and reduces the need for personnel Lot of research projects are being executed Large investment budget	Strong need for new development to increase the market Strong need for skilled technicians Low total turnover
Opportunities	**Threats**
Promising Technology Knowledge and experience available Large Potential Market	Too little innovation power and knowledge No large manufacturing industry in NL Large Competition

6.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

6.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

By the development of robots that are the collaborators and assistants of humans, new industries are becoming potential users of robots. Traditionally, robots could only work in a factory. Here the environment is adjusted to the robot. This changes due to the new technology focused on human-robot interaction. In the near future a construction site, for example, can also be a working environment of a robot. The new technologies open new markets.

6.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

A real threat is the lack of innovation. This threat can be minimized by transferring the research results to the companies. Effort should be put in this transfer of the multidisciplinary technological knowledge by working together on both research projects and implementation projects. Researchers should adapt their research objectives to the needs of the companies. This will lead to more innovations in the manufacturing robotics.

6.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

A real opportunity is the large potential market due to the new markets that are open for manufacturing robotics. It should be ensured that the lack of skilled technicians will not stop this opportunity. If the lack of skilled technicians will not be solved we will not be able to transfer the manufacturing robotics to new industries. Several solutions are possible: recruiting people from other countries, in house (re)education of employees, make an effort in making students enthusiastic for technology, organize traineeships for graduates and focus on career opportunities.

6.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

A threat to the development of manufacturing robotics in the Netherlands is the large competition, especially from Asian countries. A possibility to prevent this threat to have a real impact is to fulfill the strong need for new developments. A renewal of the traditional robots by new functionalities and improved quality is indispensable.

6.4 Conclusions and Recommendations

The automotive industry is traditionally the largest user of industrial robots. Dutch companies have a strong position as sub suppliers of metal and plastics parts as well as lighting components, services and electronics to the automotive companies worldwide. To cope with the worldwide competition we have to focus on high precision, low quantity orders. In this market robots are needed that are able to produce high quality products and are highly flexible in order to manufacture products with large differences in requirements.

Unfortunately, there is a low amount of new developments while there is a large need for flexible grippers, able to randomly grip products with large shape variations. There is also a large need for better 2D/3D vision technology for a faster and more accurate recognition of products. Processing applications in Foundries like pouring and deburring are not so easy since batches are small and deviations are big. Better force control sensor technique can help in applications like this.
Existing technologies and experience in the manufacturing robotics can be used in other segments, like motion performance, high reliability and flexibility. Manufacturing robotics shares the need for flexible grippers, increased vision functionality and force control with other application areas.

Educational factors are weak. There is a strong need for skilled technicians able to develop robots, but also skilled labor able to work with robots.

Finally the economical factors are strong. With successful techniques and new development, the existing market will increase and by focusing on new applications also other markets will emerge.

7 Professional Services

7.1 Introduction

The cluster 'Professional services' covers robots that provide commercial services (business to business) to improve the performance and efficiency in a certain application area.

The application area's to be covered are:

- Logistics: e.g. Automatic Guided Vehicles or AGV's,
- Maintenance: e.g. floor cleaning in hospitals, schools, factories and offices,
- Inspection: e.g. inspection of pipelines, ducts, dikes, roads and nuclear installations,
- Security: e.g. remote monitoring in (temporary) installations,
- Defense: e.g. robots for bomb disposal, unmanned airplanes and unmanned submarines.

There is a difference in maturity between these application areas. Globally, the defense segment is the most mature, in particularly the bomb disposal robots from the USA are frequently used in Irak and Afghanistan. These robots are often remotely operated and have autonomous elements like obstacle avoidance and moving autonomously between programmed waypoints.

In the logistic area the AGV's exist for more than 15 years. The Dutch company 'Frog' participates successfully in this market. These robots autonomously drive around components in a factory environment without fixed tracks on the floor. Comparable systems can be found in hospitals to distribute medical supplies and meals. The ECT container terminal in Rotterdam is using robots to move sea freight containers. The latest development is the warehouse robot that can pick up stored goods and move to a packaging department.

1 2 3

Figure 7.1: Examples of Professional Service Robots. 1) A robot for bomb disposal, 2) Frog AGV, 3) Floor cleaning robot.

Pipeline inspection and cleaning robots for air conditioning systems are commercially available in the USA. The other segments, security and maintenance, are in an early stage. Internationally there are a few commercial floor cleaning robots available with very early stage navigation. Examples of professional service robots are given in Figure 7.1.

7.2 SWOT-Analysis

7.2.1 Social-Cultural Aspects

All robots are particularly useful to replace dull, dirty or dangerous work. Defense robots are the most obvious example: it is socially unacceptable to have large number of casualties when interfering in conflicts. For this reason a lot of R&D is driven by countries with a significant defense budget. Recently, with the nuclear accident in Fukushima, more attention has been given to robots that can safely operate in areas with a high radiation content. In practice this means an extension of the defense application.

In the non-defense application area's robots mainly replace dull or dirty work. In high-wage countries in North-West Europe and in the USA it is becoming increasingly difficult to get motivated employees for low-skilled labor. Either this work has been outsourced to low-wage countries, or it has been solved with immigrants who accept this type of jobs to get started in the labor market.

7.2.2 Technological Aspects

The first commercial robot applications have started in rather structured and static environment (e.g. swimming pool cleaners). The challenge is to make these robots work autonomously in unstructured and dynamic environments. This requires technology in the area of navigation (knowing where you are), motion planning (knowing where to go), function execution (e.g. cleaning) and obstacle avoidance. Technology R&D is required on other aspects as well. e.g. giving meaning to detected objects, human-robot interaction and teleoperation (with time delays). On a high abstraction level the technology requirements for this cluster are the same as for other professional clusters with mobile robot solutions (Agro&Food, Care). There is also a strong overlap with the navigation needs in the consumer segment, but the robustness requirements are different.

7.2.3 Political-Legal Aspects

Professional service robotics is a relatively new area, hence the liability in case of accidents in a public area is not clear. People are not used to interacting with robots. A European norm exists for the logistics sector (AGV's).

7.2.4 Economical Aspects

Robots in this cluster will be successful if the benefit in terms of performance (e.g. accuracy, stability, speed) or efficiency (labor cost reduction) is, except for dangerous tasks, higher than the cost. For many non-defense applications this appears to be the major bottleneck. Academically, many professional service robots are supposed to be feasible, but the high cost of robust sensors and the very high development cost of robust navigation software in combination with the high operating costs causes many business cases to fail.

7.2.5 SWOT-table

In Table 7.1 you can find the Strengths, Weaknesses, Opportunities and Threats.

Table 7.6: Results of the Internal and the External Analysis: Strengths, Weaknesses, Opportunities and Threats

Strengths	**Weaknesses**
State-of-the-art know- how available in the Netherlands in the area of Navigation and Motion planning. Strong mechatronic know-how.	Lack of defense industry to drive R&D, compared to e.g. USA or Korea. Scattered application domain reducing the financial leverage of application-specific solutions. Limited amount of active companies: more activity in R&D stage than real business.
Opportunities	**Threats**
Increasing scarcity of low-skilled labor for monotone and repetitious work. Performance improvement. Productivity gain in high wage country.	Defensive reaction towards robots "stealing jobs". Safety norms not available for new applications. Lack of substantial Seed capital /Venture Capital at the necessary scale to turn the know-how into business.

7.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

7.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

Focus should be given to the development of modular solutions that can be used in several different applications. If robust indoor and outdoor navigation modules and high level motion planning software become available at much lower cost than today, many different applications could be served with feasible business cases.

7.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

If the performance or efficiency gain can be demonstrated, the innovators and early adopters will embrace robot solutions. Designing a character that people can project at functional robots will help with the emotional acceptance. 80% of Roomba (a vacuum cleaning robot) owners give the appliance a name and talk to it like to a pet.

7.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

The biggest problem is that actual scattered robot development costs lead to business cases that are financially unacceptable. The level of needed Seed funding easily exceeds the standard levels of 500 K€ in the Netherlands. Focus on those technological elements that are common between segments and clusters will lead to efficiency gains and more viable business cases: creation of more "Upside" for ventures, in other words, the possibility to create more turnover in the future, then indicated by the scope of the project. This collaboration needs to be for a large part in navigation and motion software, where background IP know-how is difficult to protect.

7.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

The standard rules of thumb of the financial sector prohibit the financing of individual robot ventures at this stage. We will need a central initiative to develop modules of industrial, high level software in the area of navigation and motion planning, in combination with financing and with protection of the IP for participants.

7.4 Conclusions and Recommendations

Many commercial initiatives in the Professional Services cluster are in 'The valley of Death' between academically proven principles and industrial solutions that are ready to be commercialized. Collaborative innovation, aimed at jointly reducing development costs and hardware costs, will pull some of them through. A strong central coordination with financial support is needed to realize this.

8 Meta-Analysis

This chapter presents the meta-analysis, on social-cultural, technological, political-legal and economical aspects of the Dutch robotic situation, followed by the strengths, weaknesses, opportunities and threats. This leads to the 'main areas of attention' and the 'conclusions and recommendations'.

8.1 Introduction

This Meta-analysis is performed over the clusters agro and food, care, cure, domestic services, manufacturing and professional services. The attendees of RoboNED Seminar 3 had the opportunity to give their input on the overall strengths, weaknesses, opportunities and threats. The outcome of these inputs together with the SWOT-elements applicable for all clusters are the basis for this meta-analysis.

8.2 SWOT-analysis

8.2.1 Social-Cultural Aspects

The Dutch society will have a large problem in due time in providing healthcare, agriculture and industry with enough personal to keep the economy running. In 2050 it is forecasted by CPB that the amount of people above 65 years old in the EU is 50% in comparison to people of 15-64 years old. Robotics might provide a solution for this problem. In healthcare this problem is the most urgent due to combination of this problem with an increasing need for care. Care robots can take over tasks where human understanding and contact is not necessary or even not wanted, like assisting in toileting. A care robot can also be very helpful in assisting in heavy fysical work, like lifting people. In this way we are able to be more careful with our care profesionals.
Agro-robotics enables a sustainable development of agricultural production by solving challenges like shortage of labor, growing production costs, competition on the international market, poor labor conditions, poor labor image, food safety and product quality and efficient use of resource and reduction of emissions of chemicals to the environment. Without the use of robots in agriculture the current up-front position in this sector might be lost.
As a potential negative emotion exists in society with respect to the intensive deployment of technology in taking care of people and food production, this needs pro-active attention. It might be turned into an advantage by focusing on positive effects of robots on independence of elderly, quality of life, food safety, animal health, and the negative image associated with illegal labor.

8.2.3 Technological Aspects

Investments might not only be necessary for healthcare and agriculture but might also be beneficial for the total innovation power of the Netherlands. Internationally, the Netherlands is highly rated in the field of high-tech mechatronic research and has a good representation with innovative technological companies. The links between companies and knowledge institutes are direct and short. These ingredients provide a unique chance to collaborate in the development of technology into commercial products.

Technological area's, in which research should be increased and collaboration is indispensable, are:

- Navigation and Motion Planning;
- Sensing and Perception;
- Compliance and Interaction Control;
- Human-Robot Interaction and Haptics;
- Learning and Adaptive Systems;
- Energy and Lightweight Materials;
- Software Engineering for Robotics and Automation;
- Safety for Service Robots.

8.2.3 Political-Legal Aspects

Beside technological investments, there are important non-technological investments necessary. A common problem for every application domain is the shortness of engineers able to develop robots, in addition to clear and focused business cases (winners). On a different level, people should be educated to be able to work with robots. Educational institutes should provide their students a curriculum that is adjusted to the future working environment, including the use of robots.

To provide a good integration of robots in society, legal issues like liability should be clearly defined and a safety mark for robots should be further developed. Hence, acceptation of robots can be stimulated by these measures. The public discussion on the ethical issues of robotics should be run based on knowledge and reality.

8.2.4 Economical Aspects

At national level there is enormous potential due to the larger high tech companies Philips, ASML, Thales and NXP. Philips is an important player in the field of service robots and develops, produces and sales o.a. robotic vacuum cleaners. The Netherlands has a lot SME companies involved in robotics, like Demcon which realizes high-tech mechatronic systems and products e.g. applied in healthcare robotics. Other companies selling and developing robots are for example Focal Meditech, Assistive Innovations and De Koningh Medical Systems. A real leading position for the Netherlands is the dairy and cattle market which extensively uses robotics, for a large part provided by the international operating company Lely. Another robotic market is agriculture, where for example companies like Jentjes and Aris are active. This market is very important due to the leading position of the Netherlands in this market in terms of productivity and efficiency.

8.2.5 SWOT-table

In Table 8.1 you can find the overall strengths, weaknesses, opportunities and threats.

Strengths	Weaknesses
Good cooperation climate Good international contacts Good research groups on mechatronics and robotics Experience from industrial robot industry Up-front in agriculture Up-front in mechatronic industry Focus on medical robotics by SME's	Too few engineers Fragmentation of investments in robotics Gap between academia and industry No clarity on safety and liability Too few investment possibilities No clarity on ethical issues
Opportunities	**Threats**
Improvement of labor conditions and employment Improvement of quality Much collaboration possibilities Improvement of the innovation power Large international expected growth Improvement of the competition position Large national market due to ageing	Society is not open for robots Too little innovation power and knowledge Asian countries are ahead Too few Dutch OEM's Too complicated business cases

8.3 Main Areas of Attention

In this chapter we confront the elements of the internal analysis with the elements of the external analysis, resulting in main areas of attention. In every quadrant, we will focus on the most important item.

8.3.1 Offensive Quadrant: Strengths versus Opportunities

How can we leverage strengths to benefit from opportunities?

Robotics brings the Netherlands the opportunity for large improvements on several social issues like labor conditions, labor capacity and quality of life, but also on economical issues like, product quality and innovation power. The strength of the Netherlands is the agricultural sector. The agro-food chain is among the main contributors of the Dutch economy. Another strength is the high-tech mechatronics industry. This sector is a subsupplier of robot systems. The up-front position of the agricultural sector and high-tech mechatronics industry can be leveraged by the use of robots. The improvement robots will bring on labor conditions, labor capacities and the innovation power will strengthen these sectors even more.

8.3.2 Defensive Quadrant: Strengths versus Threats

How can we use strengths to minimize the impact of threats?

A threat is the lack of innovation power and knowledge in the individual SME's in the Netherlands. Due to the multidisciplinary technological knowledge needed, in-house development of a robot is not possible. One of the strengths which can minimize the impact of this threat is the good cooperation climate together with the short distance to the excellent research groups on mechatronics and robotics. The SME's and knowledge institutes can enlarge the innovation power of the Netherlands by transferring the knowledge to the SME's and collaborate on the implementation of the technology in a product.

8.3.3 Reinforcing Quadrant: Weaknesses versus Opportunities

How can we ensure weaknesses will not stop us from opportunities?

Internationally a large growth of the market is expected, in particular on professional and personal robots. Nationally there is a large market due to the ageing population. This is a large opportunity. It should be ensured that the gap between academia and industry will not stop this opportunity. A solution for the missing step between technology development and commercialization, namely product development should be found. Suggestions for solutions can be found by establishing engineering consultants companies specialized in robotics. Another part of the solution can be to stimulate research institutes to develop technology beyond the proof of principle and first prototype. A solution can also be found in the further development of public-private collaborations like LEO – centre for service robotics.

8.3.4 Retreating/Turn around Quadrant: Weaknesses versus Threats

How can we fix weaknesses that can make threats have a real impact?

A threat is the complicated business cases and the immature ecosystem in particular in healthcare, but also in domestic and agriculture. The weakness of having too few investment possibilities should be fixed to prevent this threat to have a real impact. Earlier it was stated that collaboration on the level of technology is needed. Collaboration on financial level is also needed. The costs and risks of the development of new systems are too high for an individual SME and should be shared. By making clear appointments within a joined business case, the uncertainty on the costs in relation to the benefits of a new robot system once it is in operation can be taken away. This will pave the path for a better ecosystem.

8.4 Conclusions and Recommendations

In particular in health and agro&food, robotics will be indispensible in the future. In these fields robotics is a great opportunity. Cross-domain collaboration on technological and economical challenges will be a key-issue. Therefore, it is of great importance to the development of robotics that the existing eco-system will be further developed and academia-industry collaboration will be improved in order to transfer the opportunities into commercialized products. A strong central coordination with financial support is needed to realize this.

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