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ROBOTICS IN HUMAN SOCIETY – CHALLENGES ON EMPLOYMENT

Abstract

Robotics has made a dramatic inroad in our factories. So far Service Robotics is still in its infancy. On the other hand most western societies face a growing share of an 60+ population. To understand the trends and how current industrial and service robotics will develop and what its effects are on society, a large number of factors can be investigated:

- *The aging problem of western societies.*
- *The relationship between flexible automation with robotics and unemployment.*
- *The rising cost and need for healthcare and the use of service robots for medical/therapeutically applications.*
- *The availability of skilled labor, affordable workforce and immigration*
- *The benefits of using robots versus loss of labor and unemployment caused by robotics*
- *The geopolitical economic interests driving new developments*

The combined analysis will highlight the upcoming trends of robotics in general and industrial robots, service robots and military robots, UAV's in specific.

Keywords: *Robotics, industrial robot, aging population, robot applications, unemployment, robot density*

1. Related works

Robots have been around in industry since the last century and the industry keeps growing. The main demographic problem that our societies face is that of the growing share of aging population. These forecasts are given in[1]. Wise studied the effects on retirement and society, factors that are also in play when using flexible automation[2]. Bloom analyzed the aging population in Japan, according to the UN[3]. Japan is currently the country with the oldest population. Peterson challenges the need for a sufficient work force to take care of the elderly[4], while Microsoft's Bill Gates foresees a future with

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[1] http://www.helpage.org/resources/ageing-data/global-ageing-statistics/. Accessed Dec 2011.
[2] Wise, David A. and Gruber, Jonathan, "*Social Security and Retirement Around the World",* Chicago: University of Chicago Press and OECD (2006), *Live Longer, Work Longer.*
[3] David E. Bloom, David Canning, and Günther Fink "*The Graying of Global Population and Its Macroeconomic Consequences*", Department of Global Health and Population, Harvard School of Public Health, October 2009.
[4] Peter G. Peterson, "*Gray Dawn: How the Coming Age Wave Will Transform America — and the World*" *by* New York: Times Books, a division of Random House

(service) robots in every home by 2020 and beyond[5]. The IFR foresees a continued growth in the robotics industry, and provides data on robot density per country[6].

Shelton investigated the Research and Developement (R&D) expenditures of China vs. its strategic counterparts like the US[7]. Park et al report on nursing robots in Korea and their future development[8]. Rensma investigates the growing market for service and health care robotics[9]. Lopez relates a similar growth in health care robotics to industrial robots[10], while Struijk reports on modularity build for light weight robots[11]. Sakakibara reports on the positive future of industrial robots following IFR meetings in 2011[12]. Liveris investigated the need for countries to investment in flexible automation as a mean to remain competitive[13].

A recent study by Gorle mentions the creation of 3 million jobs by robotics[14]. Ford advocates the 'Luddite fallacy' and its consequences for unemployment due to full automation[15]. Tabbarok comments on the (non)relationship between rising automation and rising unemployment[16]. In the service robotics field, the sector of air applications is highlighted. The growing segment of Unmanned Aerial Vehicles is growing and Hoffman investigated the cost reduction of UAV exploitation[17].

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[5] quote by Bill Gates, on UN News Centre, http://www.un.org/apps/news/story.asp?NewsID=12287&Cr=robot&Cr1= , accessed December 2011.

[6] "World Robotics 2011", International Federation of Robots, http://www.ifr.org, , Chart of *' Annual industrial robot sales per region'.*

[7] R. D. Shelton and P. Foland, "*The Race for World Leadership of Science and Technology: Status and Forecasts",* shelton@ScienceUS.org , 12th International Conference on Scientometrics and Informetrics, Rio de Janeiro, July, 2009, and published in full in the conference proceedings.

[8] Hyun Keun Park, Hyun Seok Hong, Han Jo Kwon, and Myung Jin Chung "A Nursing Robot System for The Elderly and The Disabled" , Portland State University, http://www.ee.pdx.edu/, accessed December 2011.

[9] Arjen Rensma, "*Healthcare: The Road To Robotic Helpers"*, ScienceDaily, August, 2009, http://www.sciencedaily.com/releases/2009/08/090807091200.htm, accessed December 2011.

[10] Antonio López Peláez, "*Prospectiva, robótica avanzada y salud Laboral*", published nr 6-2000, p14 to 21. Website of INSHT, Department of Sociología III: Tendencias Sociales Facultad de Ciencias Políticas y Sociología. UNED.

[11] Bob Struijk, "*Robotics In The New Era, Challenges On Robot Design*", Debreceni Műszaki Közlemények, March 2011, HU ISSN 2060-6869.

[12] Shinsuke Sakakibara, IFR President, publication of the study "*World Robotics 2011 - Industrial Robots*", http://www.worldrobotics.org/, accessed December 2011.

[13] Andrew Liveris, "*Make it in America, The case for re-inventing America*", January 2011, Publisher: John Wiley & Sons, ISBN-10:0470930225.

[14] Peter Gorle and Andrew Clive, Metra Martech, "The positive Impact of Industrial Robots on Employment", February 2011, International Federation of Robotics IFR.

[15] Martin Ford, "*The lights in the tunnel*", published by CreateSpace (September 22, 2009) ISBN-10: 1448659817.

[16] Alex Tabbarok, "*Productivity and unemployment*", December 2003, Marginal Revolution, accessed December 2011

[17] Michael Hoffman, "*UAV pilot career field could save $1.5B", March*, 2009, http://www.airforcetimes.com/news/2009/03/airforce_uav_audit_030109/. Accessed December 2011.

Szabolcsi dealt with special UAV applications both for military and non-military purposes[18]. The basic mathematical modeling problem of the human operator/pilot is outlined in Szabolcsi's paper[19]. The environment in which air robots fly is described in the article of Szabolcsi[20] using basically NASA-models. Identification of the UAV flight dynamics model is presented in article[21]. Flight path preliminary design is shown in works of Szabolcsi to provide quasi-optimal behavior of the UAV[22].

2. Introduction

Since the 1970s robots have made a dramatic inroad in our factories. Now we find robots predominantly in automotive industry, electronics manufacturing, food and beverage, metal and general industries. On the other hand the field of Service Robotics is still in its infancy. Prototyping exists but commercial roll-out has not yet happened. Most western societies face a growing share of a 60 years+ population. This group will in fact be the one of the largest demographic groups, reducing the available work force. This paper will focus on the effects of the aging of the population in developed western countries as well as upcoming powers like China. Now in 2011 society is on the brink of moving into service robots.

A graying population means more needs to take care of elderly and disabled, while at the same time puts tensions on the scarcer labor market. In both instances

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[18] R. Szabolcsi *Conceptual Design of the Unmanned Aerial Vehicle Systems for the Firefighter Applications*, CD-ROM Proceedings of the 12th International Conference „AFASES 2010", ISBN 978–973–8415–76–8, p4, 27–29 May 2010, Brasov, Romania. and R. Szabolcsi *Conceptual Design of the Unmanned Aerial Vehicle Systems for the Police Applications*, CD-ROM Proceedings of the 12th International Conference „AFASES 2010", ISBN 978–973–8415–76–8, p4, 27–29 May 2010, Brasov, Romania.
[27] R. Szabolcsi *Worst Case Flight Scenario for Unmanned Aerial Vehicle in D3-Missions*, Proceedings of the 12th Mini Conference on Vehicle System Dynamics, Identification and Anomalies VSDIA 2010, Budapest University of Technology and Economics, 8-10 November 2010, Budapest, Hungary (in Print).
[28] R. Szabolcsi *Légi robotok alkalmazása D3-missziókban,* A "XVII. Magyar Repüléstudományi Napok" tudományos konferencia kiadványa, ISBN 978-963-313-032-2, p9, 2010. november 11-12, Budapest.

[19] R. Szabolcsi *Modeling of the Human Pilot time delay Using Padé Series*, International Journal of "Academic and Applied Research in Military Science" AARMS, ISSN 1588-8789, Vol. 6., Issue 3, p(405-428), 2007.

[20] R. Szabolcsi *Stochastic Noises Affecting Dynamic Performances of the Automatic Flight Control Systems,* Review of the Air Force Academy, No. 1/2009, pp (23–30), ISSN 1842-9238, Brasov, Romania.

[21] R. Szabolcsi *Identification of the UAV Mathematical Models*, CD-ROM Proceedings of the VIth International Conference „New Challenges in the Field of Military Sciences, ISBN 978-963-87706-4-6, 18-19 November 2009, Budapest, Hungary.

[22] R. Szabolcsi *Extra-Cheap Solutions Applied for Non-Reusable Unmanned Aerial Vehicle Technologies*, CD-ROM Proceedings of the VIIth International Conference „New Challenges in the Field of Military Sciences 2010", ISBN 978–963–87706–6–0, 28-30 September 2010, Budapest, Hungary. and R. Szabolcsi *UAV Flight Path Conceptual Design.*, Proceedings of the 16th International Conference "The Knowledge-Based Organization – Applied Technical Sciences and Advanced Military Technology", ISSN 1843–6722, pp(519–524), 25-27 November 2010, Sibiu, Romania.

robotics can be and will be part of the solution. While there is a relation between increased industrial output and increased robot density, unemployment has some roots in robotics. On the other hand robotics, industrial and service robots, also creates (high skilled) jobs. Doom scenario's prevail among neoclassic economists that foresee a collapse of employment, purchasing power and in fact economies if full automation combined with artificial intelligence becomes reality.

We also see replacement of human labor skill level brought by robotics. This is true for industry where qualified workers are being replaced by 'common' robot operators but as well in the military field, especially where UAV's are concerned to be applied in dirty-dull-dangerous (D3) missions[23].

3. Ageing population and robotics

It is no news that the world's population is aging, at an alarming rate even. Longevity is increasing due to improved health care and care available for more and more people. Also in the developed world fertility rates are dropping. Its effects are manifold, as will be described in this paper.

The demographic changes will bring challenges, and some meaningful questions arise in relation with robotics. Is there a relationship between the recent growth of industrial automation, deployment of UAV's and the emerging market for service robots with respect to the aging population? Can robotics be {part of} the solution for the problems caused by an aging population? First, let's look at the facts surrounding these phenomena. According to HelpAge today[24]:

- almost **1 in 10** people are **over 60** years old.

- By 2050 **1 in 5** people in developing countries will be **over 60.**

- Even more scarier: people aged over 60 **will outnumber children** aged 0-14 by 2050.

Besides all the demographical, environmental and social issues that a growing aged population brings, this paper will focus on the relationship between aging population and

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[23] R. Szabolcsi *Worst Case Flight Scenario for Unmanned Aerial Vehicle in D3-Missions*, Proceedings of the 12th Mini Conference on Vehicle System Dynamics, Identification and Anomalies VSDIA 2010, Budapest University of Technology and Economics, 8-10 November 2010, Budapest, Hungary (in Print). and R. Szabolcsi *Légi robotok alkalmazása D3-missziókban,* A "XVII. Magyar Repüléstudományi Napok" tudományos konferencia kiadványa, ISBN 978-963-313-032-2, p9, 2010. november 11-12, Budapest.

24 http://www.helpage.org/resources/ageing-data/global-ageing-statistics/. Accessed Dec 2011.

the need for robotics. If we look at the relationship between age and workforce availability we see a common picture as displayed in Figure 1.

	Age group					
	25 - 54		55 - 64		65+	
Region	Men	Women	Men	Women	Men	Women
World	95	67	74	40	30	12
Developed Regions	92	78	65	46	15	8
less developed regions	96	64	77	38	37	14
Europe	91	80	58	39	9	5
Asia	96	64	76	37	34	11
North America	91	76	70	59	21	13

Figure 1. Labor force participation rates, 2008, by Region, gender and age group.

It is clear from this table that labour force participation declines faster in developing regions than in other rural and/or less developed areas. Europe in particular has a low participation rate at higher age levels. It is these factors combined that are alarming, with the population aging more and more, it means that less human labour is available for reaching the required levels of industrial output in Europe and in the developing countries in general. Then there is also the need to take care and support of the elderly and disabled.

For workers with pension coverage, rules governing pension entitlement have a strong effect on timing of withdrawal from the labor force. Also many European countries operate with a mandatory retirement age, and push out older workers at a certain age. Wise showed that in addition to the push factors, there are also financial incentives to retire at the national official retirement age[25]. Factors like long-term disability, sickness and employment benefits played a strong role in facilitating early retirement in some developed countries. If we look at Asia, we see that Japan currently has the largest share of old age people in the world, with 27 percent of the population aged 60 and over.

Following a UN report cited by Bloom [3,] it is estimated that this figure will rise to 44 percent by the year 2050. In fact more than 70 countries, representing about one third of the global population, are expected to have an old-age share exceeding Japan's share of 27 percent today.

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[25] Wise, David A. and Gruber, Jonathan, "*Social Security and Retirement Around the World",* Chicago: University of Chicago Press and OECD (2006), *Live Longer, Work Longer.*

COUNTRIES WITH THE HIGHEST 60-AND-OVER POPULATION SHARES 2005 & 2050

	2005		2050
	IN %		IN %
JAPAN	27	JAPAN	44
GERMANY	25	KOREA	41
ITALY	25	SINGAPORE	40
SWEDEN	23	GERMANY	40
GREECE	23	BOSNIA	39
BULGARIA	23	ITALY	39
LATVIA	22	CUBA	39
PORTUGAL	22	PORTUGAL	38
BELGIUM	22	BULGARIA	38
AUSTRIA	22	POLAND	38

Figure 2. Countries with highest population share, Source UN 2009.

In the above figure we clearly see the problem arising in the coming decades for countries like Japan, Korea, Germany and Italy. With 60+ population shares of 40% and over, this represents a large group of elderly people who, in general terms, consume more than they will contribute. Apart from creating problems in availability of medical and social resources it means also a strain on the availability of workforce, as birth-rates are declining. Oddly enough these are also G-7 country members, relying heavily on export (machine building). If we take a look at the BRIC zone, and in specific China and India we see the following picture.

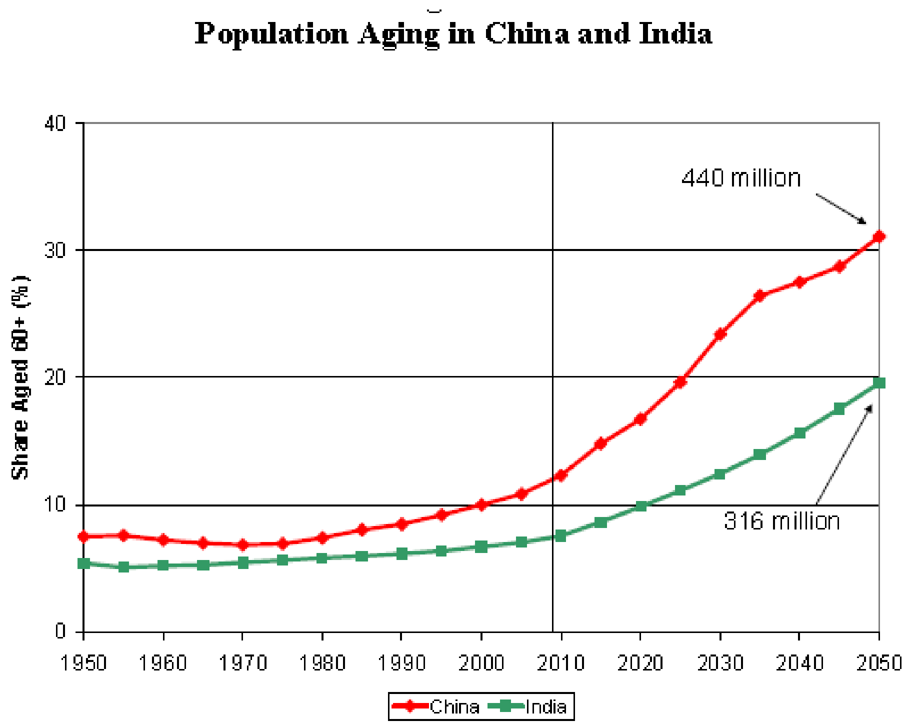

Figure 3. Population Aging in China and India.

Here we can see both China and India have today a modest score in share of over-60+ population. However, it is also clear from the expectation displayed in the graph that China's population will age exponentially the coming decades, rising well above the 30%. With strict birth rates of max. one per family this might jeopardize its economic prospects. In absolute numbers this is a staggering 440 million Chinese aged over 60 in 2050. With the continuing economic growth rates of China, every industrial platform of industrialized countries will be challenged.

As Peterson stated already around a decade ago, a situation where there is a lack of available human labor combined with a need to provide socially, economically and medically for a growing group of elderly and disabled is not an economically sustainable situation[26]. Solutions of course are at hand. A step already underway in some western countries is the raising of the so called 'exit point' of active labor. The age at which we retire is going steadily up from 65 to even 70 years, but this policy is only adapted in a few countries. Another solution is that the work force has to be enlarged.

Figure 1 shows also the clear gap between active men and active women. By employing more women the growing gap between needed and available work force can be reduced. To whatever extent this can be realized is questionable. Enlarging the work force can also be achieved by immigration. This option however is discarded as it would

[26] Peter G. Peterson, "*Gray Dawn: How the Coming Age Wave Will Transform America — and the World*" *by* New York: Times Books, a division of Random House

require too high numbers to compensate for the aging population and is politically not supported when large volumes are considered. Automation, using industrial and service robots, could be the new pillar.

According to Microsoft's founder Bill Gates, we will have a robot in every home by 2020[27]. He considers the development of the robotics industry in the same way that the computer business did 30 years ago. If we look at the current population share crossed with current robot density (robot density is the number of robots per 10.000 workers) we come to the following grid.

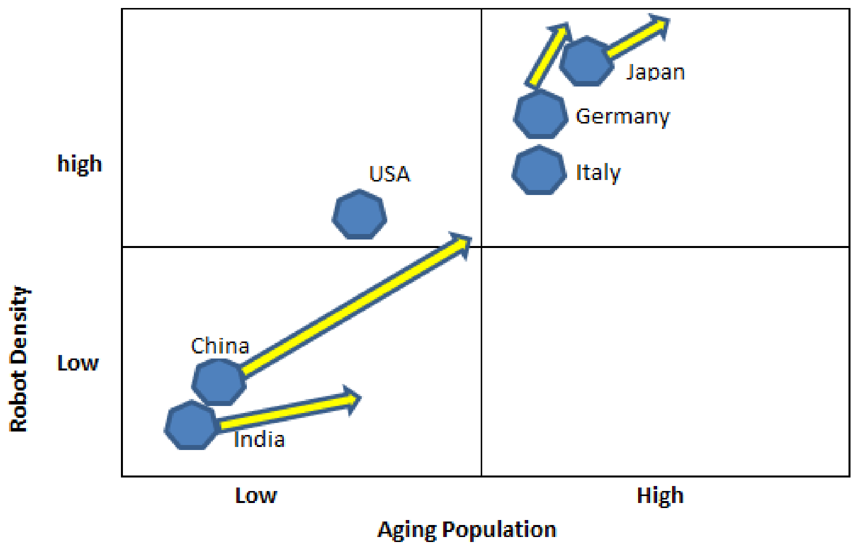

Figure 4. Robot Density vs. share of Aging Population

Where today Japan has the highest 60+ population share, today Japan is also the country with the highest robot density in the world [6]. Japan is already using robots at an unpaired level it has a robot density of close to 320. From figure 4 we can conclude that not all developed countries are in the same situation. Japan, with its aging population needs to continuously invest in Research & Development on both industrial robot side as Service Robots. The growth potential of China, and to a lesser extend India is clear. While these countries too will undergo changes in population, they can benefit from the experiences and advances made in other countries to grow their robot densities faster and steeper.

The BRIC countries can benefit most from investments in automation as their economies are expanding while their population is aging. Shelton in 2005 [7] pointed out

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[27] quote by Bill Gates, on UN News Centre, http://www.un.org/apps/news/story.asp?NewsID=12287&Cr=robot&Cr1= , accessed December 2011.

that the R&D investments or gross expenditures on research and development made by china already are with 18.9% double digit and has been doubling real R&D investment about every six years. Compared with a mere 1.7% for the US and 2.2% for the EU, in absolute values China spends approximately 1/3 of the European amount, and ¼ compared to the USA. Of course it is only a matter of time before China catches up and takes the role as world's leading country.

Oddly enough, China has today no own industrial robot brand. It might not be a surprise that Taiwan based company Foxconn (Hon Hai Precision Industry Co.) announced plans to begin building industrial robots. They plan an initial number of one million industrial robots for its own factories. This represents roughly the sum of all current industrial robots installed. Foxconn now employs more than 300.000 workers. A million industrial robots made by Foxconn will nearly double the number of industrial robots in the world. It could put China at the top of the automation industry. For western developed countries like Germany and Italy it will be more difficult as living standards are already high and the share of "over 60+" active population is too low in competitive terms towards other nations, as seen in figure 1. Europe does have a roadmap, R4H or Robots for Healthcare, to investigate the areas and manners to use technology as an answer to the challenges of the aging population. In Europe health care automation will most likely start in surgery by all kinds of robotic systems. Service robots will be a second approach to assist elderly and people with disabilities.

In Japan there already exist a very high acceptance level for robots and automation in general. The jump from toys to toy robots to finally service robots is therefore not very large. What might be unacceptable today in Europe; elderly tended by a service robot, in Japan this is a likely scenario. Nurse robots in Japan and Korea already assist elderly and service robots are being introduced on a small but growing scale[28]. These robot assist elderly and disabled people to live more or less independently and provide some entertainment. Improvements are being made on face detection, sound localization among others.

Examples are not far off. In fact, during the recently held International Robot Show in Tokyo (Nov. 2011 IREX), several operational and prototypes of service robots were shown. An example of the use of service robots in daily life is illustrated in picture 1. Here a humanoid robot is used -instead of humans – as practice patients for dentists in training. The displayed robot is a 10 axis robot - named Showa Hanako 2. It has a silicon skin and has speech recognition capabilities. It can listen and react to commands given to it by the dentist in training. Also it is able to simulate among others, openings of the mouth and eyes, express fear etc. The tongue itself has two degrees of freedom and the robot can even simulate natural movements and choking. The robot even gets tired of holding its mouth open.

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[28] Hyun Keun Park, Hyun Seok Hong, Han Jo Kwon, and Myung Jin Chung "A Nursing Robot System for The Elderly and The Disabled" , Portland State University, http://www.ee.pdx.edu/, accessed December 2011.

Picture 1. Dentist trainee Robot - Showa Hanako 2.

As the example shows, the advantageous are numerous, and the fields of application can be manifold. The aging of the various populations is therefore an area for growth for automation and robotics. In Europe the field of medical purpose robots is also being pushed ahead. According to Rensma, member of the Dutch innovation agency TNO, this industry could be worth anywhere from €40 billion upwards, as the attraction for authorities trying to plan for increasingly ageing societies is enormous[29]. Lopez estimates that the development of service robots will follow a similar path as that of the industrial robots[30]. Wishful thinking or a reality, in any case today there is still a gap between the R&D prototyping and commercial roll-out of service robots.

Struijk given account in [31] that robots used for medical purposes are now built in a modular form. These robots have become scalable towards the required application, and can be tuned via parameter settings. Indeed similar as can be found in industrial robots. In addition, versatility for medical robots is achieved by adding dedicated

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[29] Arjen Rensma, "*Healthcare: The Road To Robotic Helpers"*, ScienceDaily, August, 2009, http://www.sciencedaily.com/releases/2009/08/090807091200.htm, accessed December 2011.

[30] Antonio López Peláez, "*Prospectiva, robótica avanzada y salud Laboral*", published nr 6-2000, p14 to 21. Website of INSHT, Department of Sociología III: Tendencias Sociales Facultad de Ciencias Políticas y Sociología. UNED.

[31] Bob Struijk, "*Robotics In The New Era, Challenges On Robot Design*", Debreceni Műszaki Közlemények, March 2011, HU ISSN 2060-6869.

instruments to the robot's universal end effector and wrist design and adapting its many internal control sensors. Again an experience gained from industrial applications. Worthwhile mentioning are the developments pushed by the US chip manufacturer Intel. Intel has set up a division dedicated to home automation and elder care.

Its HERB project (Home Exploring Robotic Butler) aims at overcoming the existing gap between current service robotics and application of robotics in ordinary homes through mapping, searching and navigating through indoor environments. Here also industrial robotics elements and experiences are applied to develop commercial and practical service robots. It uses a Segway as a mobile platform and Barret arms and hands for articulation.

In summary it can be concluded that the industrialized developed countries are using their lead in industrial robots to enter the field of health care and service robots. The market needs translated through the decline of the workforce and aging of the population is clear. Flexible Automation will play a key role in the coming decades to transform robots from sophisticated machines into tools we use in our daily life, as we have a car, PC or smartphone.

4. Is robotics creating or destroying labor?

With the prices of (industrial) robots falling, the cost of labor rising, and the technology continuously improving, the demand for robotics keeps growing. According to Sakakibara robot sales in 2011 will rise approximately 18% to about 140,000 units[32]. This means a new peak level, while a continued increase will happen in the period between 2012 and 2014 of about 6% per year.

Sales will reach levels of about 167,000 units in 2014. This means that the operational stock of industrial robots operating in the factories world-wide will increase to about 1.3 million units at the end of 2014. One can argue that these robots have taken the place of manual labour.

To a certain extent this is probably true. Robots are indeed used to replace human labour, i.e. robotised arc welding vs. manual welders, pick & place robots vs. human pick and packing lines, robotised load/unload of machines vs. factory workshop labour, automated paint booths vs. manual painters, automated meat cutting vs. butchers. The list is probably endless. Labour volume in manufacturing indeed decreased over the last decade.

And, this none withstanding the fact that while a sharp increase in automation and robotics occurred also the industrial output increased. So the reduction in labour

[32] Shinsuke Sakakibara, IFR President, publication of the study "*World Robotics 2011 - Industrial Robots*", http://www.worldrobotics.org/, accessed December 2011.

has been offset by higher productivity and output, which benefits and stimulates economies and thus labour participation.

A larger and a higher degree of flexible automation in our factories create a higher output, and so shifts labour from factory floor to services oriented labour.

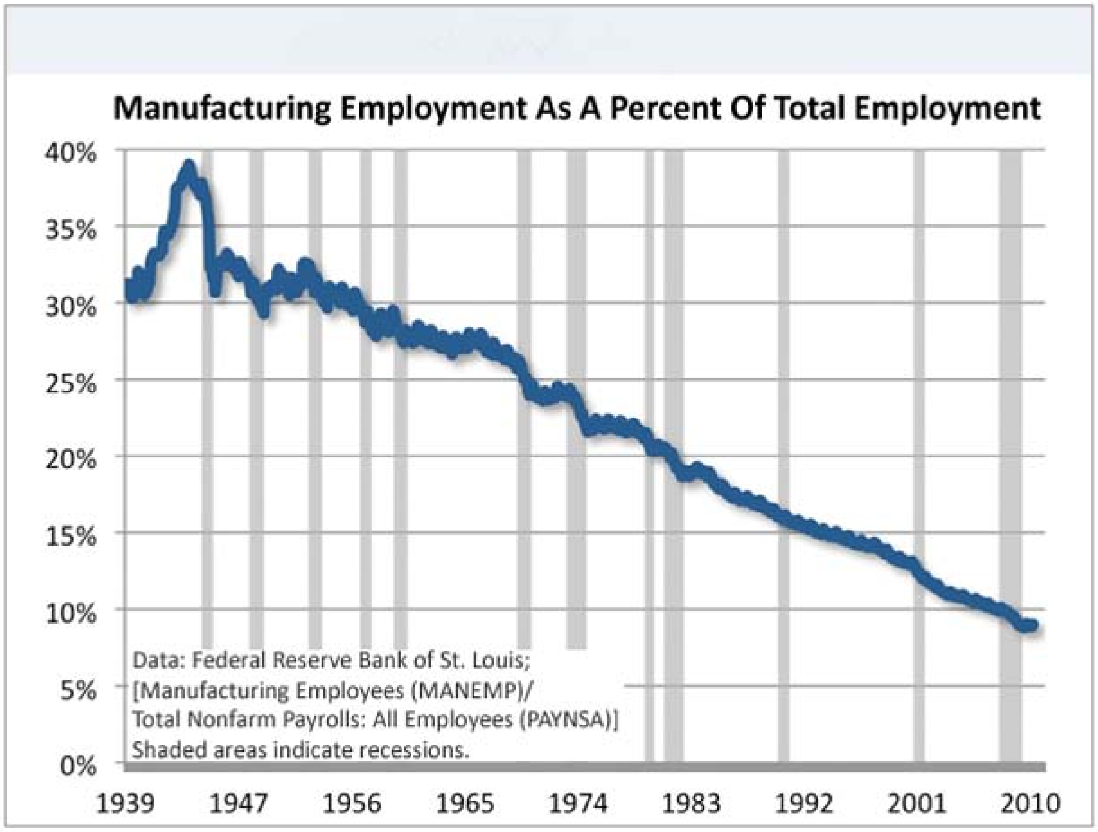

Figure 5. Manufacturing share of Employment in US.

Figure 5 shows the increased downward trend of manufacturing share as a percentage of the total employment in the US over the past decades. It shows that even in periods outside recessions the share is falling.

Since 2000, when the US ‘only’ had a robot density of 52, the manufacturing share dropped from 13% to less than 9% in 2011. Its robot density went upward from 52 to 110. Output rose 9% over the same period. Unemployment increased, but only sharply during the last crisis, starting 2009, see Figure 6.

So it can be concluded that the use of industrial robots does have an effect on the share of employment in manufacturing, but not on the total. According to Liveris nations must focus on investments in automation for manufacturing to stay competitive[33]. Germany is hailed as a positive example, a high-wage country that has revived its advanced-manufacturing sector. It was able to convert its trade deficit of $5.9 billion in 1998 to a trade surplus of $267.1 billion in 2008.

The German government invested in advanced manufacturing, and those investments are paying off. According to a recent study by Gorle the approximately one million plus industrial robots currently in operation have been directly responsible for the creation of close to three million jobs[34].

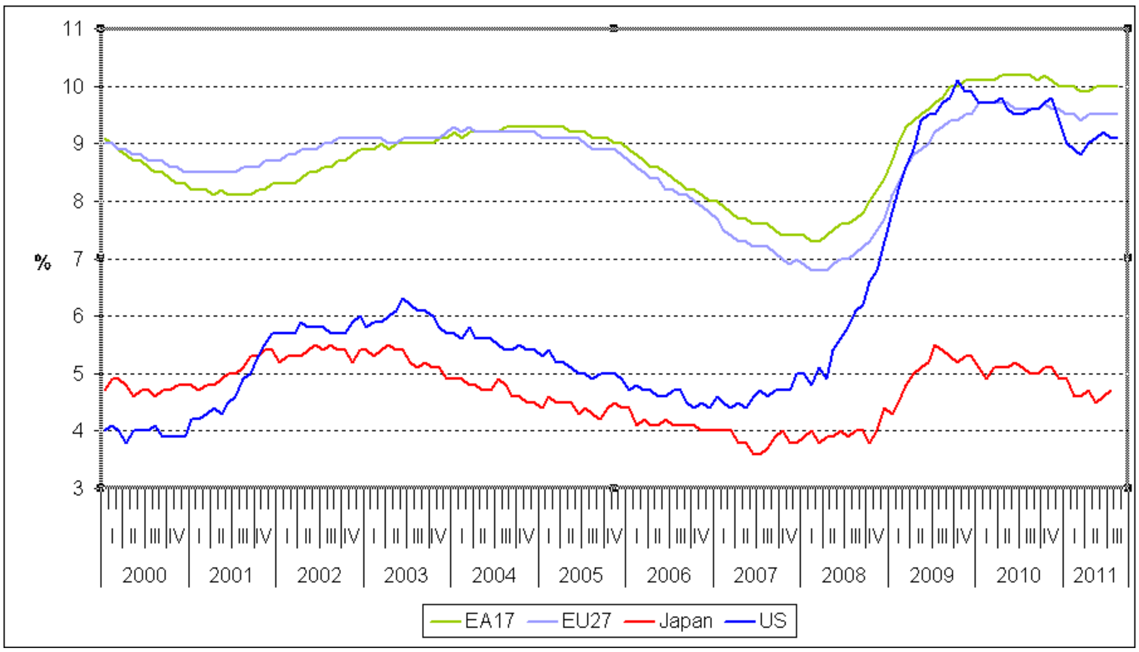

Figure 6. Unemployment as share of total per region.

These jobs come of course from the newly created robotics industry itself. Here we find the various robotics manufacturers, their sub-suppliers for i.e. reducers and gear boxes. In addition we find a large group of large and SME (small medium enterprise) as line builders and/or system houses, responsible for the integration of the robots into work cells. Next is the group of end users, as robots need to be operated and maintained. Also, the growth in robot use over the next five years will result in the creation of one million high quality jobs around the world. So according to this study, robots will help to create jobs in some of the most critical industries of this century: automotive, consumer

[33] Andrew Liveris, "*Make it in America, The case for re-inventing America*", January 2011, Publisher: John Wiley & Sons, ISBN-10:0470930225.
[34] Peter Gorle and Andrew Clive, Metra Martech, "The positive Impact of Industrial Robots on Employment", February 2011, International Federation of Robotics IFR.

electronics, food, solar & wind power, and advanced battery manufacturing to name just a few.

If we would include the indirect jobs, the employment grows even more. Increased robotics market signifies a positive expanding effect towards indirect growth of labor. Here one can think of the increase in volume for transport companies, business travel, restaurants, shops etc. In total robotics can be attributed to 8 to 10 million jobs.

Critics to this viewpoint do exist. Ford claims that we are closing in on a tipping point with automation[35]. If we automate even more, the economy cannot absorb the newly unemployed due to automation in other sectors and hence it would reduce the purchasing power of the people.

Unemployment will rise (and is rising) more and more through the automation of many service jobs, like automated bank/airport tellers, self-checkout cashiers in supermarkets, on-line shopping vs. true shopping. The growing group of unemployed people would simply not have enough purchasing power to consume the products brought forward by the economy. This would push for even more price decreases, and more automation. It is a vicious circle. It would in fact comply with the so called "Luddite fallacy", the neoclassical economic belief that labor saving technologies will ultimately lead to mass unemployment and an over-automated society where manufacturers take and.

The original Luddites were early 19th century English textile workers who smashed the new textile machines to protect employment[36]. Clearly automation in textile in the 19th century did obviously not stop the economy, employment and output from growing. Nor did it happen with the automation of agriculture and that of car manufacturing. On the other hand there were other manufacturing industries to absorb the employment. In a theoretical sense an all automated society would lead to the Luddite fallacy. According to Tabbarok there is no correlation between unemployment and automation[37]. Reversely, productivity growth leads to higher real wages and lower unemployment. Full automation as requirement for the Luddite fallacy, will not and cannot be reached due to various factors. The main ones are:

- Technical limitations, (dynamics, cycle time, processing power limitations)
- Small batch series (flexible automation is not 'flexible' enough)
- Poor Cost/Benefit ratio or too high ROI on robot investments (It can be made but is not economically viable)

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[35] Martin Ford, "*The lights in the tunnel*", published by CreateSpace (September 22, 2009) ISBN-10: 1448659817.

[36] Easterly, William (2001), "*The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*", Cambridge, Massachusetts: MIT Press. Pp 53–54. ISBN 0-262-55042-3.

[37] Alex Tabbarok, "*Productivity and unemployment*", December 2003, Marginal Revolution, accessed December 2011

- Complex Human-Machine interfaces in case of service robots (dealing with a human is not the same as dealing with an industrial process).
- The wish to deal with humans (doctors, artists, teachers, entertainment, etc).

While technology push might overcome some obstacles in the long run, on a short term basis these are valid barriers to refrain from reaching full scale automation. The benefits of robots, whether in industry or service robots are clear. The use of robots overcomes inhumane working conditions (high payload, environment with emissions, high repetitive strain) and hence stimulates production and quality of life of employees.

In addition, new industries keep emerging. Like in the Energy Sector; Bio fuel, Solar Industry, Wind Power, Lithium Battery manufacturing all need human labour, and will need automation to make it affordable. Other examples can be found in aircraft demolition, smart phones and tablet industry, bio farming and Eco tourism, all will require human labour. The rise of robotics and the change of types of human labour go hand in hand.

5. UAV's vs. human pilots

When we look at defense related robotics, there is one sector worth mentioning. Unmanned Aerial Vehicles or short UAV's have been around only recently, introduced in the second Gulf War in war theatre. Their main advantages over man-flight are clear; less risk, more autonomy and more cost effective.

While in use since 2001 in the US Army it use has multiplied by a factor 80 till 2010[38]. It function started as reconnaissance but has been extended to search and destroy capabilities. Traditionally these craft were flown by ex-fighter pilots. According to Hoffman today the US Air Force is training airmen rather than manned aircraft pilots to fly unmanned aerial vehicles[39].

This represents a huge saving, some $1.5 billion over six years. Currently the US Air Force spends more than $2.6 million to train a fighter pilot. Training for an UAV pilot would be a little more than $135,000 per pilot.

Typical a case where automation first removes humans from hazardous places and overtakes intelligent skills to be operated by 'common' skills. Not far off from the

[38] Maj. General James O. Barclay III, "*Eyes of the US Army - US Army Roadmap for UAS 2010-2035*", p1.
[39] Michael Hoffman, "*UAV pilot career field could save $1.5B", March*, 2009, http://www.airforcetimes.com/news/2009/03/airforce_uav_audit_030109/. Accessed December 2011.

earlier example given where the automotive paint lines before required highly skilled painters only to be replaced by common operators which run the robotized paint lines.

6. Conclusions

Our populations are aging at an unprecedented rate, while western societies are embracing technology to increase output and efficiency. Japan is by far the most automated country in the world, but also has the largest share of elderly. R&D Investments in automation can improve a countries competitive position while remaining a high cost country, like Germany. China's star is rising, with large growth numbers in investments, robot density, but is also facing the growing share of elderly. It is to be expected that China will equal Japan in the future when it comes to yearly installed robots. China has no own robot manufacturing but indications show that in the near future this is likely to change. Service robots will come in force, most likely to roll out commercially first in Asian countries like Japan and Korea. Their growth will follow a similar path as that of industrial robots. Although it is undeniable that robots create unemployment they also create it. An estimated total of 8 million jobs. So far the created unemployment have been (partly) absorbed by other manufacturing sectors and the growing service sector. A total automation of manufacturing would lead to huge unemployment, loss of purchasing power and thus dramatic social changes. Upcoming industries with new needs, technical and practical issues however will make this unlikely. Also the military experience a shift from skilled human labor to automation, especially in the field of UAV's. A sector which is likely to grow, and that follows the same characteristics as can be found in industrial robots.

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