The Significance of Robot Safety Standards for the Development of Life Support Robots

Material prepared for the 6th World Convention on
Robots, Autonomous Vehicles and Deep Learning:
A Review of Ethical and Social Implications of Robots

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Today's Presentation
— In Search of Collective Intelligence —

I. Introduction: Life Support Robots in a Jumble of Ideas and Prototypes

I-1. Socio-Economic Background

(1) Japan's Rapidly Aging and Declining Population
(2) Orientation toward a Tolerant and Inclusive Society without Distinction as to Age or Disability

I-2. Politico-Economic Background

(1) Budgetary Constraints/a High Govn't Debt-to-GDP Ratio
(2) Industrial Policy to Revitalize Japan

Can Life Support (or Assistive) Robots Provide Us with A Brighter Future?

"Assistive robotics opens up the prospects of a triple-win scenario for the global management of the public-health crisis posed by dementia and population ageing {1. healthcare expenditures, 2. caregiving burden, 3. the quality of life (QOL) of patients}. However, the goals of robotics-assisted dementia care could remain unachieved if social, legal and ethical questions are not addressed."

Ienca, Marcello *et al.*, "Social and Assistive Robotics in Dementia Care: Ethical Recommendations for Research and Practice," *International Journal of Social Robotics*, Vol. 8 (2016), pp. 565-573.

I. Introduction: Life Support Robots in a Jumble of Ideas and Prototypes

I-3. A Jumble of Ideas and Prototypes
(due to the Complexity of Aging Phenomenon)

Life Support Robots Should Serve the Elderly
with Well-thought-of Artificial Empathy (e.g., Elderspeak Communication)
and in Accordance with
(1) Memory Lapse
(2) Loss of Senses (Vision, Hearing, Touch, Smell, Taste)
(3) Reduction of Physical Fitness (Strength, Endurance, Agility, Flexibility)

The Current Typology of Life Support Robots in Japan

1. Wearable Transfer Aids
2. Non-Wearable Transfer Aids
3. Outdoor Mobility Aids
4. Indoor Mobility Aids
5. Toileting Aids
6. Bathing Aids
7. Monitoring Systems for Nursing Care Homes
8. Monitoring Systems for Private Homes

II. Current Situation:
Can the Leader of Industrial Robots Lead in Service Areas?

II-1. High Price, prohibiting product diffusion
II-2. Limited Demand, being unable to lead to economies of scale
II-3. Ramshackle Standards, propagating competing standards, and making the global robot market broken into pieces, and keeping each market disconnected locally

The global market for nursing care and disabled aid robots, made up of mostly Japanese manufacturers, is still tiny: just $19.2 million in 2016, according to the International Federation of Robotics. . . .

Cute, furry and responsive, Paro reacts to touch, speech and light by moving its head, blinking its eyes and playing recordings of Canadian harp seal cries. But Paro, like **most robots**, is **expensive**: 400,000 yen ($3,800) in Japan and about 5,000 euros in Europe.

(Reuters, "Aging Japan: Robots May Have Role in Future of Elder Care," March 27, 2018.)

Anecdotal reports imply that the Japan leads the world in elder care robotics manufacturing. A recent story from Fox News in the US reported, "If you grow old in Japan, expect to be served food by a robot, ride a voice-recognition wheelchair or even possibly hire a nurse in a robotic suit — all examples of cutting-edge technology to care for the country's rapidly graying population" (Fox News, 2007). . . . Major Japanese corporations, including Toyota, Honda and Panasonic, have leveraged their manufacturing expertise and financing from the NEDO initiative to develop refined elder care robotics prototypes. . . . Despite having developed technologically sophisticated prototypes, Japanese assistive robotics manufacturers have not gained any empirically measurable market lead over developers in the United States and the European Union. . . . While Japanese manufacturers of assistive robotics have demonstrated an advanced level of technological sophistication, they are still restricted by the same combination of **high prices, limited demand and lack of market standardization** that hinders market growth in the other regions of the world.

(OECD, "Robotics Innovation Challenge," 2012, pp. 28-29.)

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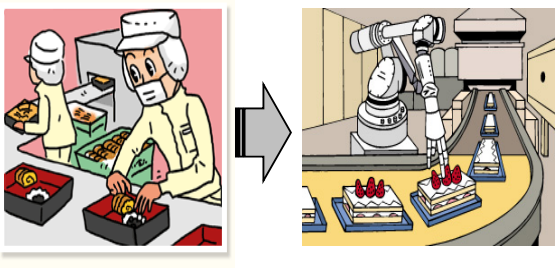
A Critical Difference in the Concept of "SAFETY" between Industrial Robots and Life Support Robots

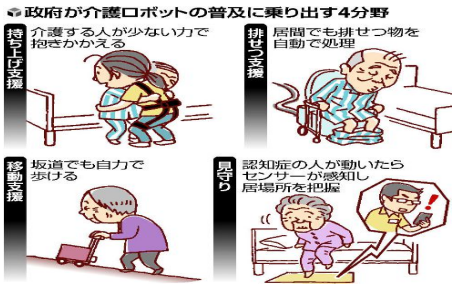
Industrial Robots utilized in capital-intensive sectors

Replacement is very easy with robots!



Life Support Robots utilized in labor-intensive sectors

Hospitals and LTC (Long-term Care) Facilities



Replacement might be very difficult because of safety issues!

Source: Prof. Yukio HONDA, With his prior permission

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III. Drawing up a Road Map toward a Higher Speed of Product Diffusion

— From the Stage of "Conceptualization and R&D" to the Stage of "Embodification and Commercialization" —

It is unlikely that ***monomaniacal*** simple cleaning robots such as vacuum-cleaning robots and robots that clean windows will turn up in large numbers in our households. . . . And again, I wonder if robotics point of view, it is very hard to build something that can effectively ***and*** safely help in the kitchen and in the living room ***and*** in the bathroom.

(Royakkers, Lambèr and Rinie van Est, *Just Ordinary Robots*, 2015, pp. 79-84)

III-1. Standardize, aiming at developing a global robot market

(1) Caregiver support robots, (2) Self-reliance support robots (3) Surveillance and Communication robots

III-2. Integrate, aiming at developing a multi-purpose robot market

(1) Independent living seniors using self-reliance support robots, (2) The elderly needing caregiver support robots, (3) The disabled such as quadriplegics and paraplegics using self-reliance support robots

III-3. Investigate, industries that would have complementary effects.

(1) Industries such as the education, medical, business services sectors that would use the same components, (2) Industries such as military sector that would cause external effects on robot markets, (3) Other policy measures such as state entrepreneurship and national innovation policies.

III-4. Draw up a Road Map toward a Higher Speed of Product Diffusion

III. Drawing up a Road Map toward a Higher Speed of Product Diffusion

— From the Stage of "Conceptualization and R&D" to the Stage of "Embodification and Commercialization" —

III-3. Investigate, industries that would have complementary effects.

(1) Industries such as the education, medical, business services sectors that would use the same components, e.g., biometric data capture devices, (2) Industries such as the military sector that would cause external effects on robot markets, (3) Other policy measures such as state entrepreneurship and national innovation policies, e.g. introduction of the gamification of eHealth devices.

A state-of-Art Robot at a Laboratory

A Smart Robotic Labo Assistant at the Research Center for Advanced Science and Technology, University of Tokyo (Courtesy of Yamato Scientific Co., Ltd.)

Especially, (2) the Unignorabley Huge Role of the Military Sector

(1) Weapons (autonomous weapon system (AWS), lethal AWS (LAWS)),
(2) Soldiers (robotic augmented soldier protection (RASR), robot soldiers),
(3) Robots for combat-injured veterans (robot-assisted rehabilitation therapy),
(4) Robotic technologies to assist combat medics,
(5) Spin-offs from military technology

IV. A Japanese Solution: Increased Function of the Robot Safety Center

IV-1. Key Elements for Successful Affordable Products and Their Diffusion

(1) Global Database regarding Product Accidents, (2) Prospective Preventive Measures against Product Accidents, (3) Continued Sophistication of Safety Standards on

(a) Caregiver support Robots, (b) Self-reliance support Robots

(c) Surveillance and Communication Robots

IV-2. Role of a Robot Safety Center in Search of Ambient Intelligence Domotics

(1) The Robot Safety Center in Japan (Est. 2010): **The World's First and Only Facility**

An ISO Working Group (ISO/TC184/SC2/WG7) is drafting the safety standard ISO 13482, which is scheduled to take effect within 2013. As a member of this working group, JARI (Japan Automobile Research Institute) has tried to have the Japanese research results reflected and has proposed a detailed test method to be added into the ISO standard.

(2) Cooperation with Other Institutions (JARI, JASPEC, JARA, JASPA)

*: JASPEC (Japan Assistive Products Evaluation Center), JARA (Japan Robot Association), JASPA (Japan Assistive Products Association)

(3) **Robot Safety Center (RSC) with a Living Lab for Sophisticated AmI Domotics**

IV-3. Issues on the Horizon: Redesigning both Smart Robots and Smart Houses

(1) Sophistication of Accident Information Database to be globally utilized

(2) Global Utilization of Safety Standardization: Caregiver Safety and Patient Safety

(4) Effectiveness Evaluation System & Standardized Verification Test

(4) Global Guidelines for Life Support Robots

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IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics

Safety Standards that would not trigger robophobia

(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-1, 2 The Current Typology of Life Support Robots in Japan

1. Wearable Transfer Aid (User: Caregiver)

Products	Developing Makers	Issues on the Horizon
Smart Suit EX	Smart Support Technologies	1. Price, 2. Weight & Size, 3. Limited wearer movement at least the current robotic exoskeleton system
Power Assist Suit	Japan Art	
Muscle Suit for Nursing Care	Kikuchi Seisakusho	
HAL for Care Support	Cyberdyne	

2. Non-Wearable Transfer Aid (User: Caregiver)

Products	Developing Makers	Issues on the Horizon
Transfer Aid Robot	Sumitomo Riko	1. Price, 2. Weight & Size, 3. Movement on uneven terrain, 4. Reduced agility of the caregiver.
Transfer Aid (Waterproof)	Sekisui Home Technology	
Transfer Care Assistance	Toyota Motor Corporation	
Transfer Support Robot Hug T1	Fuji Machine Mfg.	
Robohelper Sasuke	Muscle Corporation	
Transfer Aid	Yasukawa Electric Corporation	
Risie Assistant Robot Resyone Plus	Panasonic Age-Free	

Note: Table is primarily based on the information exhibited in "Robotic Care Devices Portal" on the Internet.

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IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-3 The Current Typology of Life Support Robots in Japan 3. Outdoor Mobility Aids (User: the Elderly)

Products	Developing Makers	Issues on the Horizon
Body Weight Support Travel Aid	Kikuchi Seisakusho	1. Price, 2. Adjustment Problems regarding the acceleration and the strength of brake that should be changed according to the user, 3. Operability on crowded pedestrian walkway
Active Cart	a Development Consortium	
KeePace	Kowa	
Robo Cart	Cyberdyne	
Walking Assist Robot	Kawamura Cycle	
Walk Assistance System	Imasen Engineering	
Otasuke Walker	Azbil	
Robot Assist Walker RT.1	RT Works	
Motor-Assisted Walker	NSK	
Motor-Assisted Walker	Nabtesco	
Tepco	Shintec Hozumi	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-4 The Current Typology of Life Support Robots in Japan 4. Indoor Mobility Aids (User: the Elderly)

Products	Developing Makers	Issues on the Horizon
RT Walker	THK	1. Price, 2. Weight & Size, 3. Narrow and stepped corridor movement, 4. Ascending and descending stairs
“Kaigo (help)＋α”	YMP-Mundus	
Indoor Movement Support Robot	Moritoh	
Walker	Mitsuba	
Indoor Mobility Aid	Yasukawa Electric Corporation	
Indoor Robot Walker	RT Works	
Yorisoi Robot	Sanyo Homes	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-5 The Current Typology of Life Support Robots in Japan
5. Toileting Aids (User: the Elderly and Caregiver)

Products	Developing Makers	Issues on the Horizon
Portable Toilet for Nursing Care	Sakai Medical	1. Price, 2. Operability, 3. Robophobia, 4. Hesitation to use a communal toilet. Agenda: "how to develop an AI-equipped Robotic for home use that incorporates the knowhow of the experienced caregiver"
Smilet Portable	Smile Nursing Care Equipment	
Room-Mounted Mobile Flush Toilet	TOTO	
Vacuum Excretion Drainage Assist	Aronkasei	
Wells Adjustable Portable Flush Toilet	Sekisui Hometechno	
Portable Toilet	NWIC	
Auto-Wrapping Defecation Treatment	Nihon Safety	
Excretion Support Robot	Okada Mfg.	
Robohelper Love-S	Muscle Corporation	
Ever Care	Parson Life	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

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Safety Standards that would not trigger robophobia
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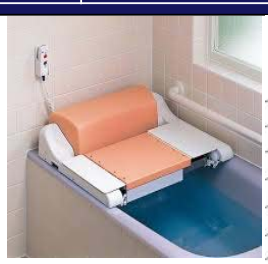
Table IV-6 The Current Typology of Life Support Robots in Japan
6. Bathing Aids (User: the Elderly and Caregiver)

Products	Developing Makers	Issues on the Horizon
Bathing Support Equipment	Hi-Lex	1. Price, 2. Operability
Bathtub-mounted Bathing Aid	TOTO	
Wells Adjustable Bathing Aid	Sekisui Hometechno	
Showering Aid	Air Water	
Lift-equipped Bathing System	OG Wellness Technologies	



Source: Prof. Yukio HONDA, With his prior permission

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IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
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Table IV-7 The Current Typology of Life Support Robots in Japan
7. Monitoring Systems for Nursing Care Homes (User: Hospital and LTC Facility)

Products	Developing Makers	Issues on the Horizon
Dementia Care Management Platform	FuRo Works	1. Privacy and Security, 2. Underdeveloped and uncoordinated technical standards, 3. Interoperability, 4. Price, 5. Upgradableness
Non-contact Monitoring System	Nissho Denki	
Monitoring Support Platform	Sharp	
Eterior Mat	Toli Corporation	
Out-of-bed Prediction & Notification	RTC	
Vital Sensing Monitoring	GOV	
Adaptive Monitoring Platform	Funai Electric	
Networked Outlet Monitoring Robot	Logical Product	
Monitoring Support Platform	Kyokko Electric	
Sleep Monitoring System	Chugai Seisakusho	
Safety Monitoring System	KogaSoftware	
Multimodal Monitoring Platform	RayTron	
Monitoring Aid System	AIVS	
Monitoring System	VR Techno Center	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-7 The Current Typology of Life Support Robots in Japan
7. Monitoring Systems for Nursing Care Homes (Continued)

Products	Developing Makers	Issues on the Horizon
Monitoring System	Noritsu Precison	1. Privacy and Security, 2. Underdeveloped and uncoordinated technical standards, 3. Interoperability, 4. Price, 5. Upgradableness
Monitoring Agent Network Robot	Pip	
Non-contact Tracking System	Ideaquest	
Monitoring Platform	Sumitomo Riko	
Silhouette Monitoring Sensor	King Tsushin Kogyo	
Medication Management Support	Clarion	
Establishing & Marketing Monitoring	Super Regional	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

An RSC with a Living Lab for Sophisticated AmI Domotics
Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

Table IV-8 The Current Typology of Life Support Robots in Japan
8. Monitoring Systems for Private Homes (User: Family Caregiver)

Products	Developing Makers	Issues on the Horizon
Motion-Sensor Wireless Monitoring	Logical Product	1. Underdeveloped and uncoordinated technical standards, 2. Interoperability, 3. Operability, 4. Privacy and Security, 5. Price, 6. Upgradableness
"Imairumo HI"	Solxyz	
Elderly Monitoring Network	Fuji Data System	
24-hour Remote Elderly Monitoring	Bio Silver	
Cloud Monitoring System	Advanced Digital Technology	
Dementia Patient Monitoring System	Carecom	
Monitoring Aid System	AIVS	
Multimodal Monitoring Platform	RayTron	
Monitoring System	Noritsu Precision	
Watching System (Bathing)	Kyokko Electric	
Monitoring and All Detection System	Netwrok 21.	
Monitoring System	CQ-S Net	
Monitoring Robot	Fujisoft	
Bath- & Wash-room Monitoring	Ideaquest	

IV. A Japanese Solution: Increased Function of the Robot Safety Center

Safety Standards that would not trigger robophobia
(e.g., operability, weight & size, durability, environmentally friendliness, upgradableness)

A Need to Establish a New Typology based on a Globally Combined Knowledge Pool of Safety Robot Standards and Operating Procedures

Table IV-8 A Proposed Typology of Life Support Robots

User-type	Function-type	Purpose-type	Specific Purposes, etc.
Caregiver Support	Mobility Assistive	Wearable	
		Non-wearable	Indoor, Outdoor, Bed Mobility
	Hygiene Care	Bathing and Showing	
		Toileting	
	Surveillance	Monitoring	
	Communication	Psychological Nursing	
Self-Reliance Support	Mobility Assistive	Wearable	
		Non-wearable	Indoor, Outdoor, Bed Mobility
	Hygiene Care	Bathing and Showing	
		Toileting	
	Communication	Call and Guidance	
	Communication	Human-Machine-dialogue	Effects on parkinsonism and dementia

IV. A Japanese Solution: Increased Function of the Robot Safety Center

—From "Made in Japan," or "Made in such country as Germany, or the US, . . ." to "Standards Set by a Global Partnership"—

IV-3. Issues on the Horizon: Redesigning both Smart Robots and Smart Houses

(1) Sophistication of Accident Information Base to be globally utilized
(2) Global Utilization of Safety Standardization in the field of Caregiver Safety and Patient Safety
(3) Effectiveness Evaluation System & Standardized Verification Test

(4) **Re-establishment of a Robot Research Center to Nurture**
an Environment in terms of Robot Friendly Ambient Intelligence (AmI) Domotics,
not only from a technological but also other perspectives—economic, gerontological, ethical, etc.

Formulate Global and Universal Guidelines for Life Support Robots
by examining AmI Domotics
from various Perspectives:

(a) The Eldery Needing Life Support Robots
(b) Seniors Neeing Self-Reliance Support Robots
(c) Caregivers Needing Assistive Robots
(d) Engineers Desining and Developing Robot Technologies
(e) Natural Scientists Studying Optimum Ways to Treat Patients
(f) Ethicists and Legal Experts Examining Legal and Ethical Standards
(g) Economists and Managerial Scientists Designing Economic Organizations

"The key thing about all the world's big problems is that they have to be dealt with collectively."
(Doug Engelbart, 2006)

Summary

Japan is the forerunner in the world in terms of aging population. Under these circumstances, life support robots are promising tools to lead to a higher quality of life (QOL) for the elderly along with physically challenged people—both young and old. However, there has been a jumble of ideas and prototypes, leading to a cul-de-sac with respect to the future development of caregiver and self-reliance support robots.

My presentation proposes a promising approach to this cul-de-sac. This impasse has been caused by three factors. First, robots are extremely expensive, unaffordable for caregivers and patients. Second, robot markets are extremely compartmentalized and isolated. Third, the primary cause of compartmentalized market has been a confusing patchwork of standards. Thus far, the cul-de-sac has brought about a lackadaisical growth of life support robots, compared with the case of industrial robots that are experiencing a galloping growth, especially in East Asia.

Accordingly, the time has come to draw up a new road map toward a higher speed of robot diffusion. The most effective approach would be the establishment of globally encompassing and trustworthy safety standards. They could provide a firm foundation for a globalized and integrated market of life support robots. Individual markets, thanks to universally applicable safety standards, would be loosely interconnected; those markets would include not only the market for elderly care, but also medical, educational, business, and military services as well as industrial robots, leading to a larger pool of components and related technologies.

The resulting larger pool could reduce the prices of life support robots and accelerate their diffusion. The establishment of globally encompassing safety standards requires an institutional framework which could play a leadership role. Japan has a robot safety center (RSC); only one in the world to systematically propose safety standards and guidelines for life support robots.

End of Presentation, Thank You Very Much

The Significance of Robot Safety Standards for the Development of Life Support Robots

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