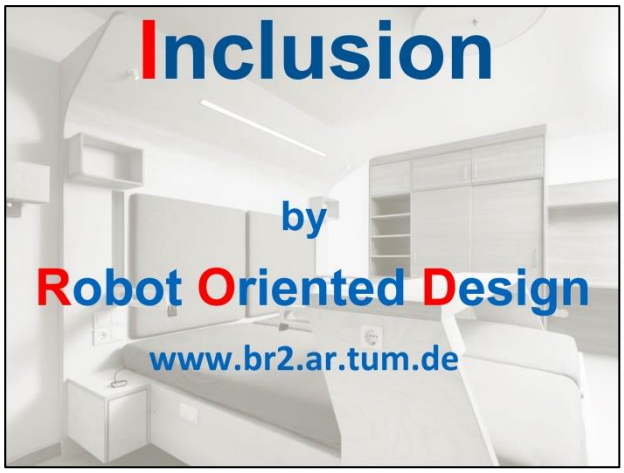
Inclusive Robot Oriented Design (I-ROD)

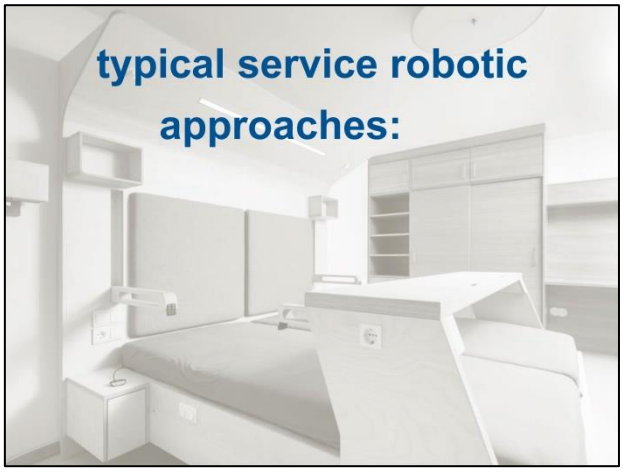
Thomas Bock (Technical University of Munich)



1. Introduction

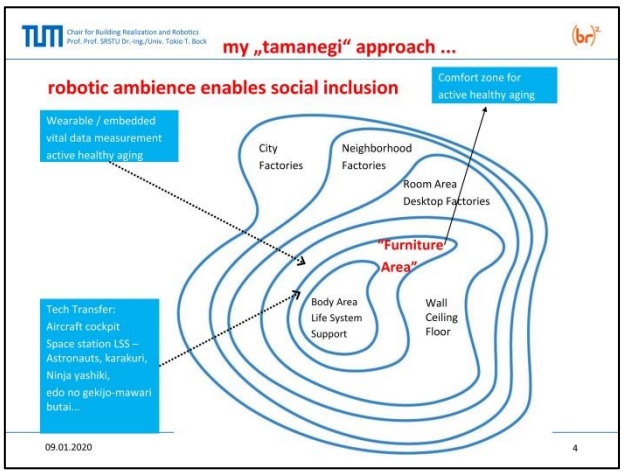
Thank you very much for inviting me, Kumagaya-sensei. Thank you for introducing me to Kumagaya-sensei and also for translating, Shibata-sensei.

This presentation is based on an idea from my doctorate at the University of Tokyo 32 years ago when I analyzed construction robotics. These are typical service robotic solutions or approaches (Slides 1-2), but my approach is a little bit different. I call it the *tamanegi* approach (Slide 3). It starts from the personal area and extends to the city level. The basic idea is that we have a comfort zone where people feel comfortable and can live a happy and independent life. This includes lots of cross-disciplinary approaches from different disciplines in order to allow mobility, independent work, and life support systems (Slide 4). We end up in social inclusion (Slides 5-6). This is the most important thing to be realized in society by this ambience consideration of robotic technology.



Slide 1

Slide 2



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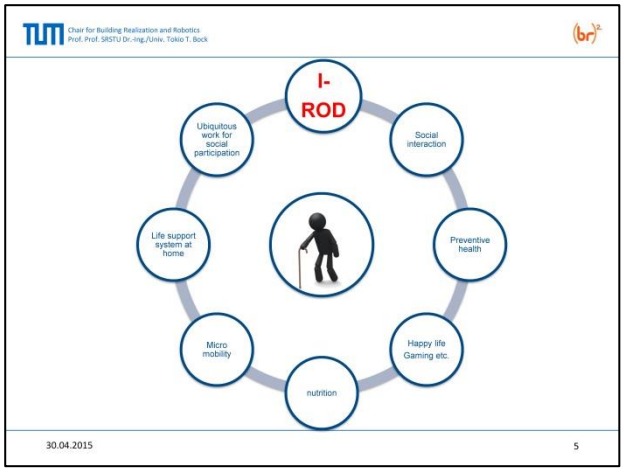


Slide 4

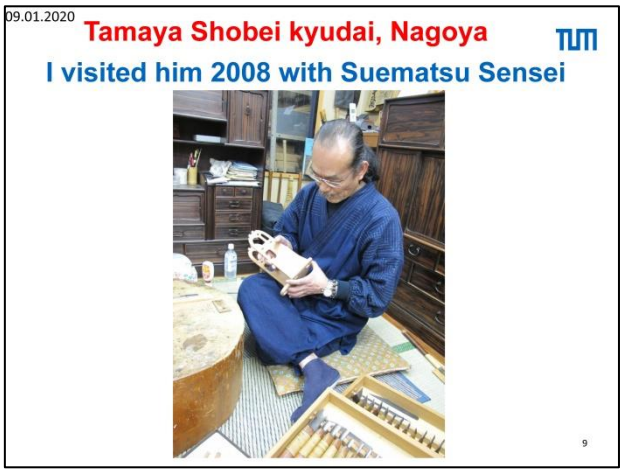
Slide 5

Slide 6

2. Inspirations from Japan

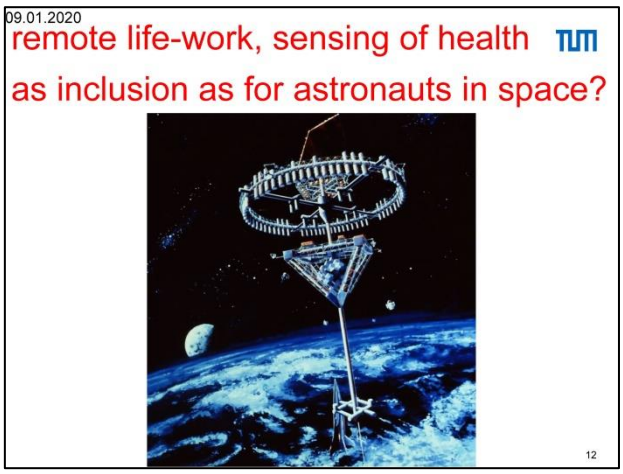
I got some inspirations while I lived here for five years between 1984 and 1989 (Slide 7). I was amazed by *gattai* and built some models. I was also inspired by *edojidai no gekijo*, the mechanical theater, and *mawari butai*, which were invented in Japan. I also visited Tamaya Sobei Kyudai , a ninth-generation karakuri master in Nagoya (Slide 8) introduced by Professor Suematsu. He explained to me all the secrets of *karakuri*-making. Japanese karakuri is very special. It is very different from French automata (Slide 9). French automata work continuously, but Japanese *karakuri* does not. It has some irregularities and can be programmed, adjusted, or customized to what you need. It is a very interesting approach. In fact, this *ocha motteiru karakuri* is something like a hybrid car. It charges itself by the weight of the *ocha* cup, propels itself and travels around the *tatami* mat. Tamaya Shobei Kyudai and Professor Suematsu also explained *mawari butai* from *edo no gekijo* (Slide 10).

Slide 7



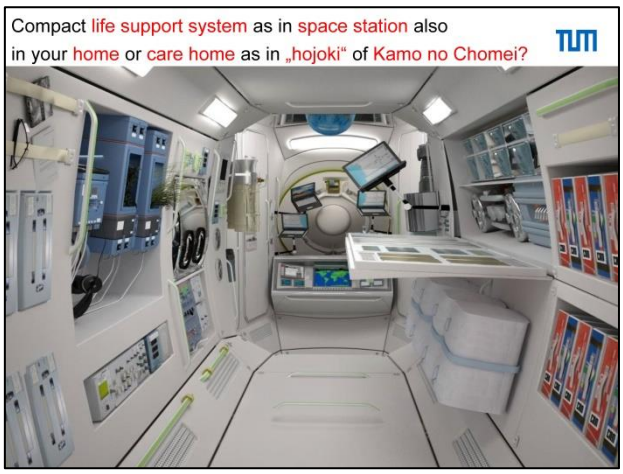
Slide 8

Slide 9



Slide 11

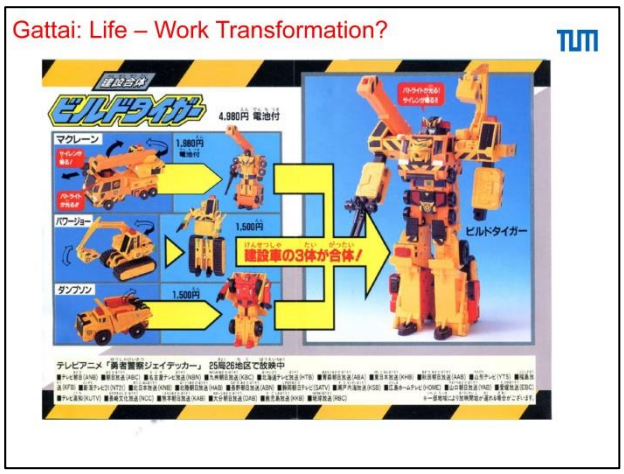
Slide 10



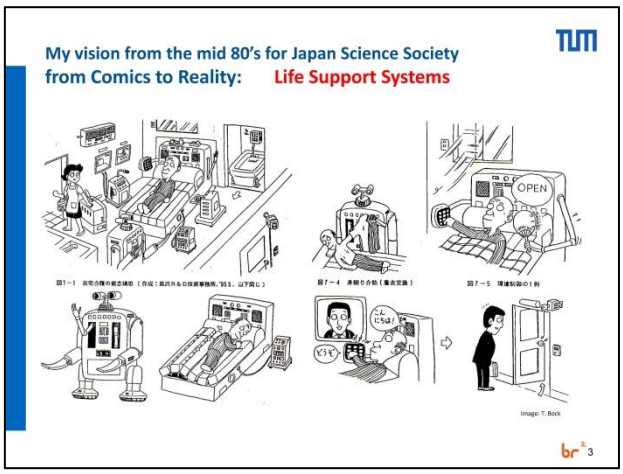
Slide 12

I was also inspired the Space Station when I worked sometime for Professor Larry Bell, director of the environmental center of University of Houston, to design the NASA Tech House (Slides 11-12), which was the preceding prototype research building for Biosphere-2 in Arizona. In space, whether its on a space flight, or in a space station or in a spce colony, you need a life support system to check the health of astronauts when they are far away from ground control on earth. The idea is that you can get the health data almost real time to be processed and diagnosed in the control center. We need a similar system also for telemedicine to check the health of people who live by themselves especially in remote areas or are contained or locked up due to pandemic reasons.

Gattai, which can change into different shapes, is also a concept we need for the life cycle of future transformable environments and infrastructure and buildings which last for about hundred years (Slide 13) to allow their adaptability in time enabling social inclusion and also sustainability by constantly adjusting its functions to actual needs of citizen. Imagine you are living in a house from a baby until old age. The building cannot adjust, but *gattai* can.



Slide 13



Slide 15

3. Social Inclusion by Robotic Ambience

Robot Oriented Design is very important for good quality of life, working and mobility (Slide 14). I had a project about 35 years ago for the Japan Science Society. I sketched some manga and actually I implemented some of these later as I will show you today (Slide 15). Basically, when you look at a building, the structure and wall is made of concrete, bricks or timber, steel etc. (Slide 16). It is just a passive construction material. What I am doing is to try to embed active systems like microelectronics, microsystems, mechatronics, and even some parts of robotics into the passive building system to make it like a service-performing building system.

Slide 14

Category	Category	Subsystems	Planning components/ Scope
Physical	Classical "passive" subsystems	**Building structure**	Bearing structure: steel concrete, brickwork etc.
		Building infrastructure	Water pipes, cables, air circulation, energy generating modules etc.
		Building modules	Walls, columns, windows, doors, ceiling etc.
		Surfaces	Painting, stucco, plastering, textures etc.
Digital	Emerging "active" subsystem	**Mechatronic systems**	Wall cabinet lift, worktop unit lift, kitchen appliance lift, liftable toilet
		Embedded micro systems	Sensors, actors: sensor floor, heat sensors etc., sensors for health conditions
		Wearable/ Implanted Devices	Sensors, actors in the body area, sensor shirts, implanted sensors/ actors
		Intelligent appliances	Controllable lights, refrigerator, washing machine
		Interfaces	Touch screens, voice mail, communication devices, mobile phones
		Robotics	e.g. robotic bed Panasonic
		Mobility Systems	Intelligent wheelchairs, Toyota i-swing, Toyota I-Unit, HAL Cyberdyne
		ICT Enabled Applications	IT platforms, monitoring/ tracking systems, ambient intelligence, pro-activity
		Physical & Digital Services	Care services, supply with goods, supply with information, emergency alert/call etc.

Slide 16

For example, we embedded sensors in the armrest of this chair (Slides 17-19). Old people like to sit in chairs, watch TV and simultaneously you can check their health automatically. The chair can also transform into an exercise machine, so you do not just sit in front of the TV and become lazy. This is inspired by *gattai*. It changes into a different thing.

Slide 17

Slide 18

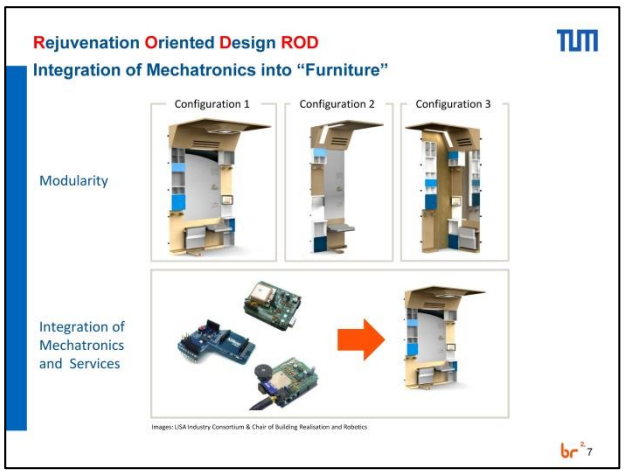
Slide 19

This is another project (Slides 20). It becomes a rowing exercise device. You can also sense the blood pressure through the armrest and through the textile. You do not need to put anything like a handcuff for blood pressure measuring etc. any more on your arm.

Slide 20

Old people do not want to move from their apartments where they spent most of their life. What we do is refurbish the old apartment so they can stay there because they are used to their beloved environment. And we add some pre-fabricated modular furniture which are very slender and thin so we can place it even in a small apartment or narrow corridor. We add microelectronics or microsystems into the furniture so it becomes a very active infill system for an existing apartment (Slides 21-22).

Slide 21



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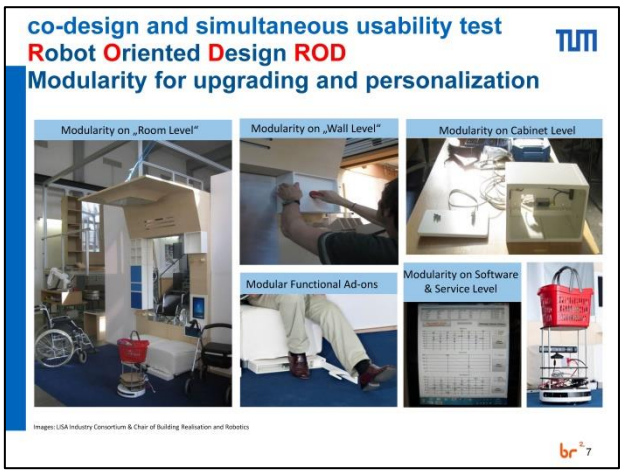


Slide 24

We build prototypes and ask the elderly to test it. It is a kind of co-design and co-creation (Slide 23). We built sensors that check people in order not to forget their key or wallet when they leave their apartment. We build all these kinds of sensor ourselves and then test them together with people for usability.

Slide 23

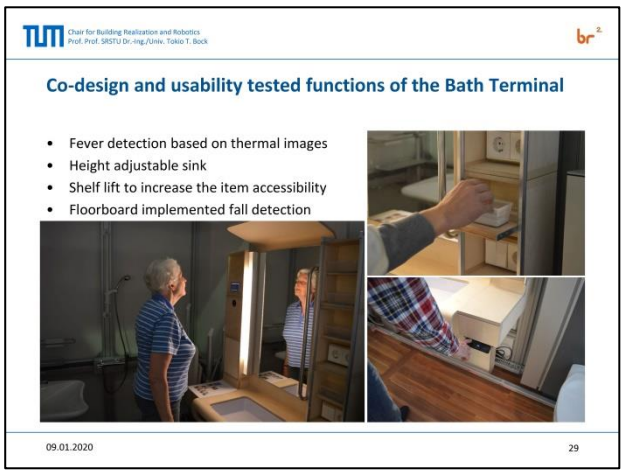
Here is another prototype for taking off and putting on shoes, which is difficult for the elderly (Slide 24). There are similar prototypes for the bedroom, the bathroom, the dining room, and the entrance to the wardrobe where you leave your shoes or coat (Slide 25). Everything is embedded with sensors for health parameters.

Slide 25

Here again, we co-design, co-create, and test usability with the elderly. Near the Technical University of Munich, we have a care home with 600 rooms, so they are very happy to come and check our prototypes (Slide 26). This device, for example, is to help you to get out from the bed (Slide 27). I do not like this device, but it is just for checking before building a different mechatronic furniture prototype. This is another example (Slide 28). You can test whether she has a fever by remote sensing while she is putting on makeup in the bathroom.

Slide 26

Slide 27



Slide 28

We also have sensors for fall detection (Slide 29). Seventy percent of falls happen at home, so we implemented a fall detection system based on lasers, later infrared, and then finally with LED to reduce the cost. It has become very thin, so we can place it anywhere in the future. We also use some very simple robotics between the kitchen and the dining table (Slide 30). When you have fallen, a robot will come to check whether you are okay, but we do not normally use robotics very much. Rather, we use embedded robotics.

Slide 29

Slide 30

We develop our own sensing (Slide 31). For example, within the textile, while you sit on the chair, we can sense your blood pressure and pulse rate through your pants or skirt, so you do not need to go to the doctor. That can also be helpful for telemedicine.

Slide 31

After several cycles of prototyping and usability testing, we disassemble it and ship it to care homes (Slide 32). We design it in such a way that we can assemble it very quickly. We only disturb the people who live in the care home or at home for 30 minutes and then the system is functional.

Slide 32

This is one was developed for the testing in real care homes in Italy (Slide 33). The bridge designed across the bed moves and pulls you up, so you do not need an ugly crane to lift you up from the bed. The bed also changes for the dining (Slide 34). The bed as the chair furniture checks your health, here again, when you place your arm or when you sit on the chair or lie in bed (Slides 35-36). To get out from the bed, now you do not see the ugly device (Slide 39). It is now integrated into the bridge over the bed. This one is for putting on and taking off your shoes. It lifts up your feet or your body because elderly people are sometimes very weak in the knees.

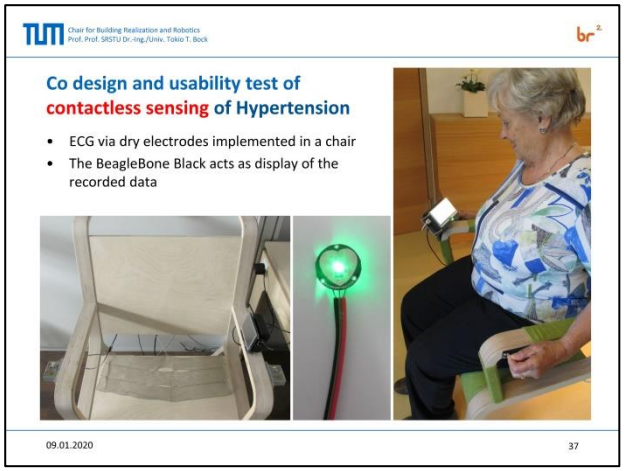
Here, the bridge moves back and forth and pulls you up, so you do not have the ugly lifting device (Slide 40).

Slide 33

Slide 34

Slide 35

For the wardrobe, it is difficult for some people to put on a jacket, so we developed this device to help (Slides 37-38) you putting on and taking off your shoes and jacket.



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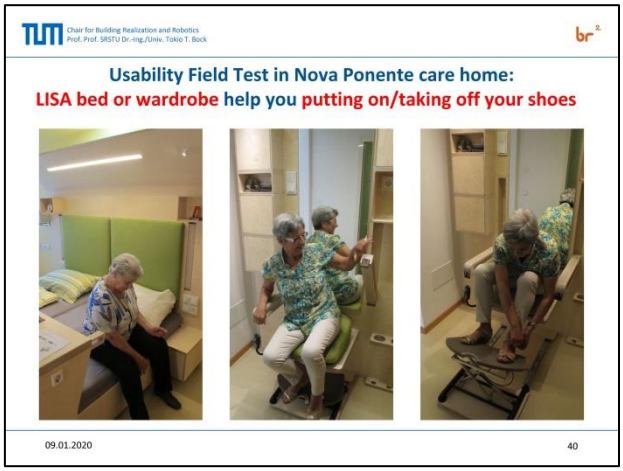

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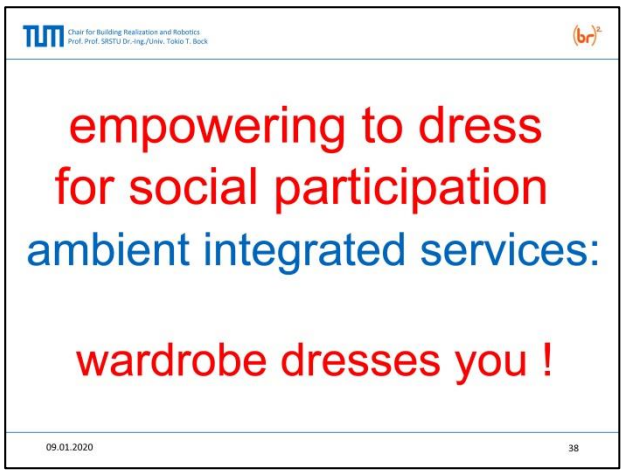

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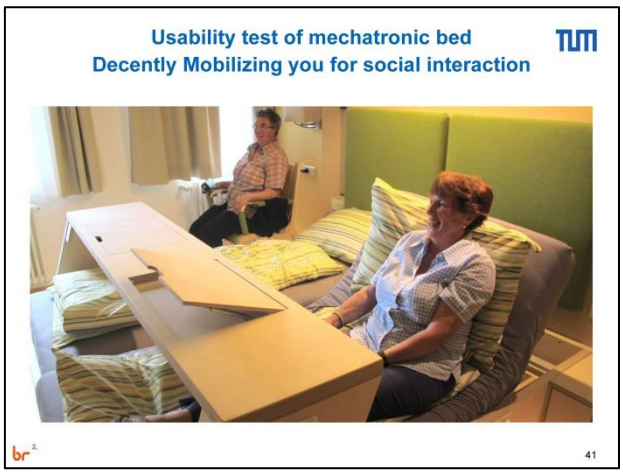
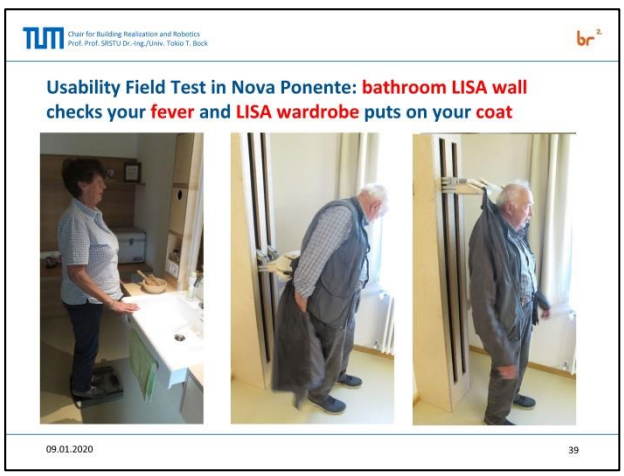


Slide 40



Slide 38

Again, many test cycles in two different care homes in Northern Italy (Slides41-44).

Slide 41

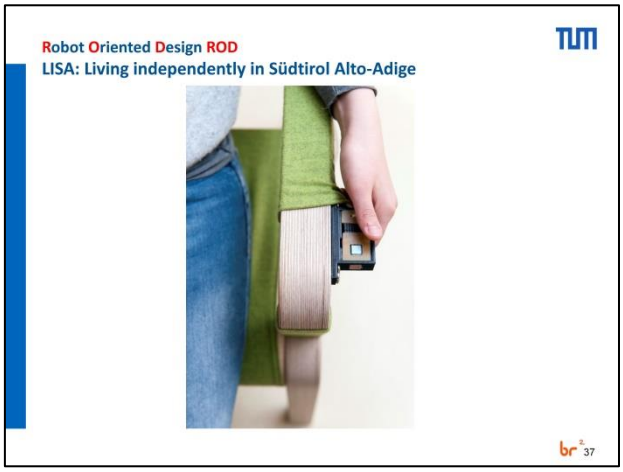
Slide 42

Slide 43

Slide 44

Since I am an engineer (from IIT Chicago)-architect(from University Stuttgart) who got into robotics (at the University of Tokyo) I asked an industrial designer from Milan to design this furniture because it has to look good (Slide 45). All the devices we can see are very ugly. I do not want to use them myself if I get older. I took care of the technology and the robotics, as well as the embedded mechatronics, microelectronics, microsystems, and contactless sensing. The designer from Milan took care of the design. Mr. Kofler of Nova Ponente was a skillful cabinet maker. Mr Terzariol as industrial designer got the Compasso d'Oro award for this work. The Compasso d'Oro is a very hard-to-get design award in Italy. It is very competitive in Italy because they have many good designers. He got it because of this furniture. This is a sensor in the armrest (Slide 46), and this is a robot bringing food to the dining table (Slides 47-48). You can see other examples as well (Slides 49-53).

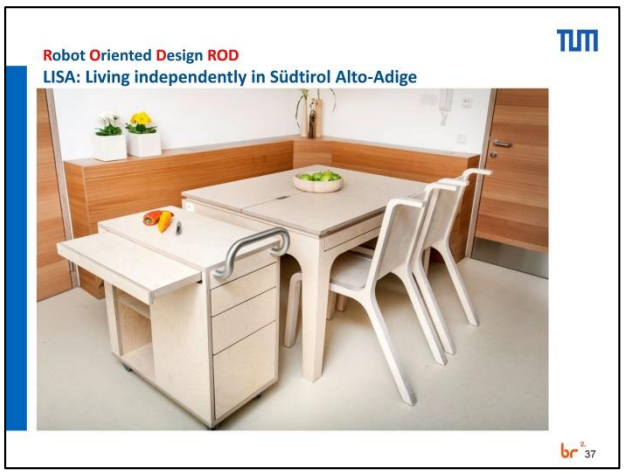
Slide 45



Slide 46

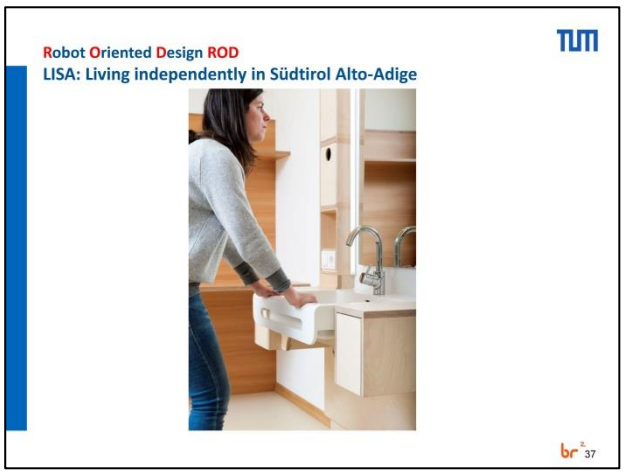
Slide 47

Slide 50



Slide 48

Slide 51



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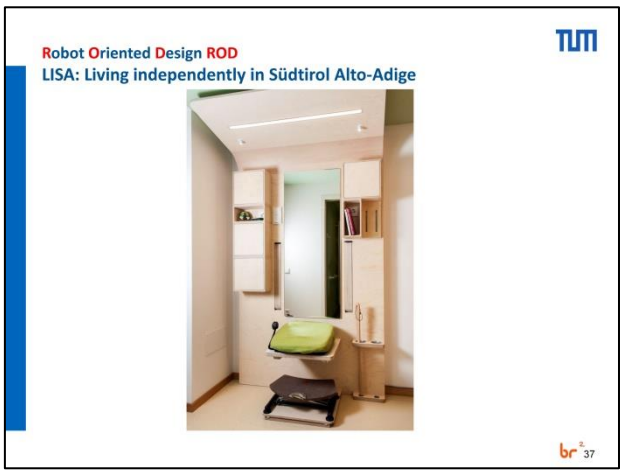

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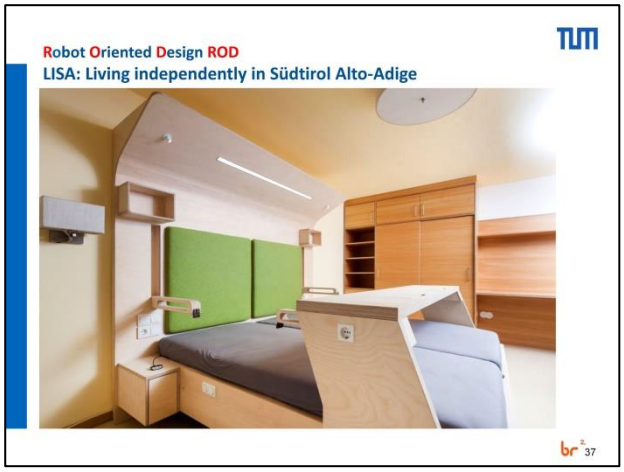

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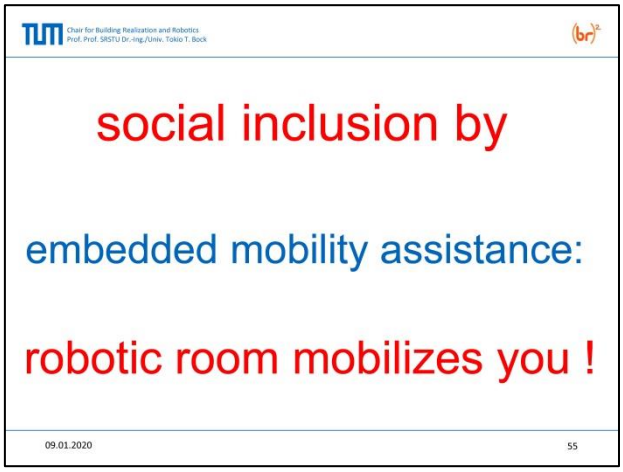
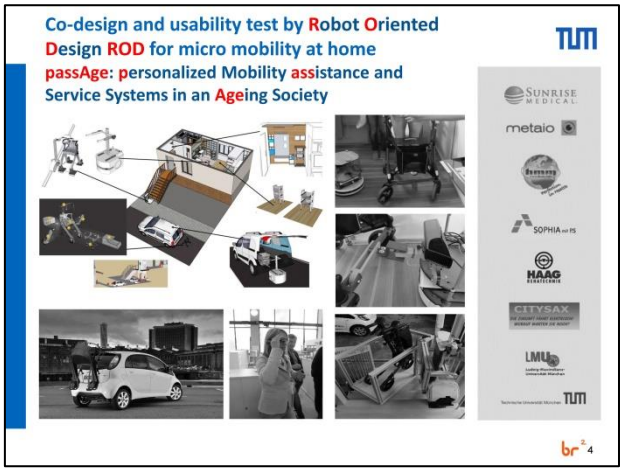


Slide 54

4. Social inclusion by embedded mobility assistance

Now, I will talk about mobility (Slide 54). As I mentioned, 70 percent of accidents happen at and at close range around home (Slide 55). We focused on the front entrance area and the inside of the apartment because that is where most of the accidents happen. I built this setup in my research lab in Munich. We checked different devices, but they were not so helpful (Slide 56). A brain researcher told me, "You still have to be active and walk yourself because it is related to the brain," so people walk up- or downstairs, but if they stumble, we can catch them. It is like an old type pulley bar ski lift. It holds you around your hip so you cannot fall downhill. You can also bring any kind of luggage or wheelchair or walking device. In the compartment we added to travel along and twist around for up-or unloading.



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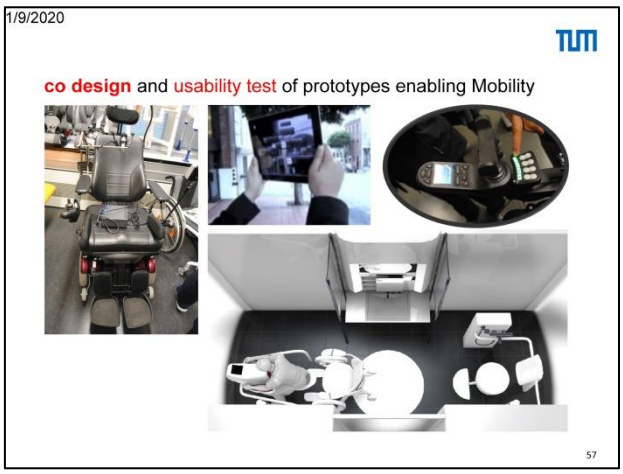

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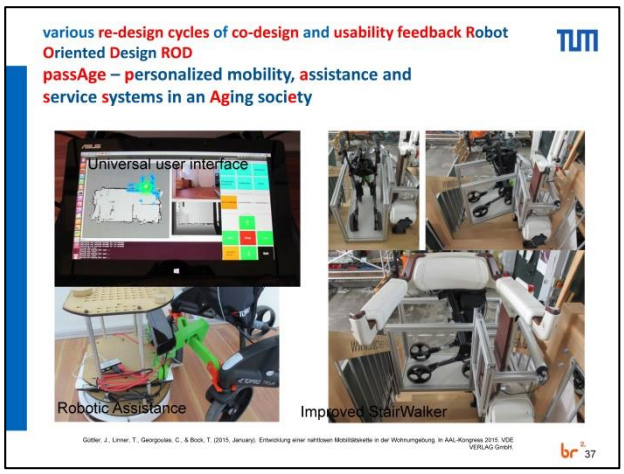
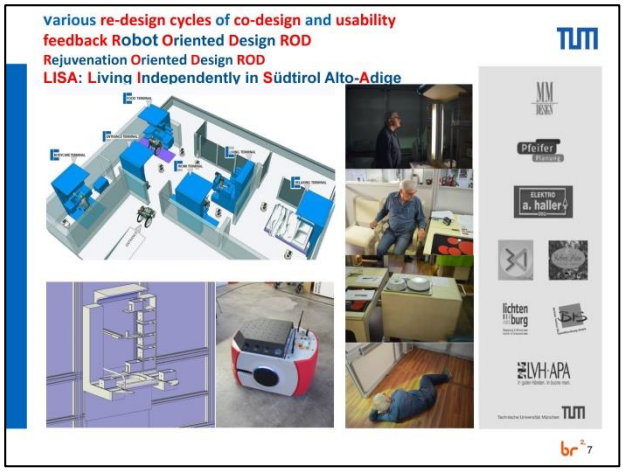


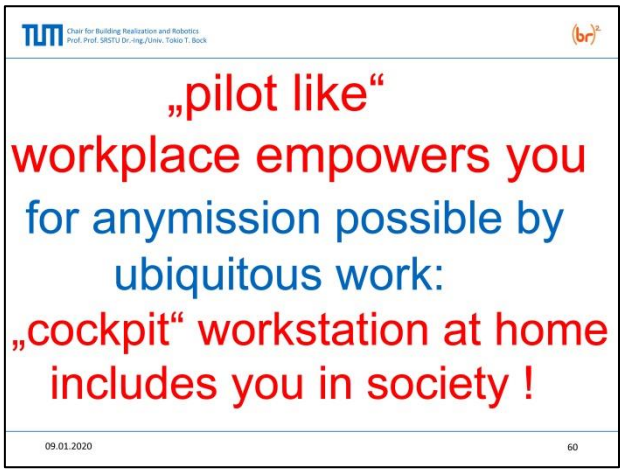
Slide 57

You can choose different kinds of units for the bedroom, the dining room, the kitchen, and so on (Slide 58). Everything is modularized, so you can decide. Also, you do not need to buy it. You can also lease or rent it or the health or the health insurance or pension fund could provide it.



Slide 58

Moreover to improve social inclusion, people should actively work and be involved in the work process (Slide 59). The idea was inspired from an aircraft cockpit (Slide 60) when I took my commercial pilot license in Dallas Love Field airport in 1979. While I was watching somebody in a wheelchair, I decided on this aircraft cockpit-like workstation (Slide 61) because you can produce anything while sitting in one place just like a pilot flying a 100 mio. Dollar aircraft from his cockpit seat. There are a scanner, an area where you and the robot can work together, and a 3D printer. We measured task load levels (Slide 62). It is criteria from NASA which check the stress level of astronauts when they are flying in space. We used the same method and found that it is very difficult for people to program and control the robot, so we developed a gesture control mechanism. With a very cheap Leap Motion sensor you can control the robot just by hand gestures. Even if people have a tremor, we can filter it out and still use the signals for controlling the robot (Slide 63). We tested it and it worked very well (Slide 64). This is the NASA method (Slide 65). We measured the stress level during the task.



Slide 59

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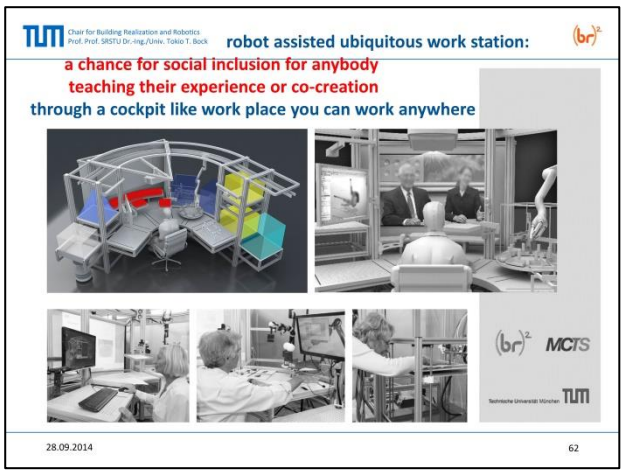
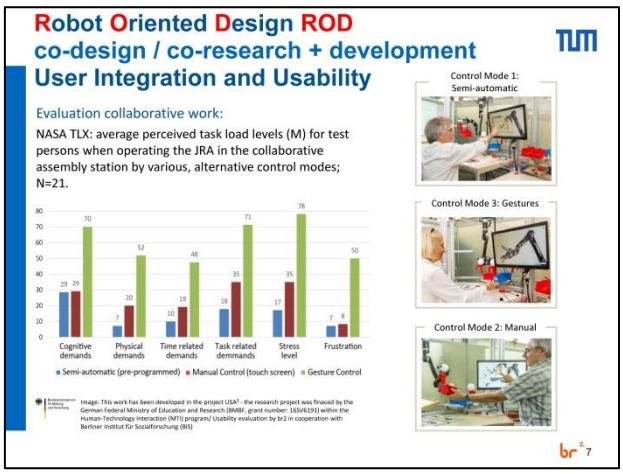


Slide 61

Slide 64

Slide 62



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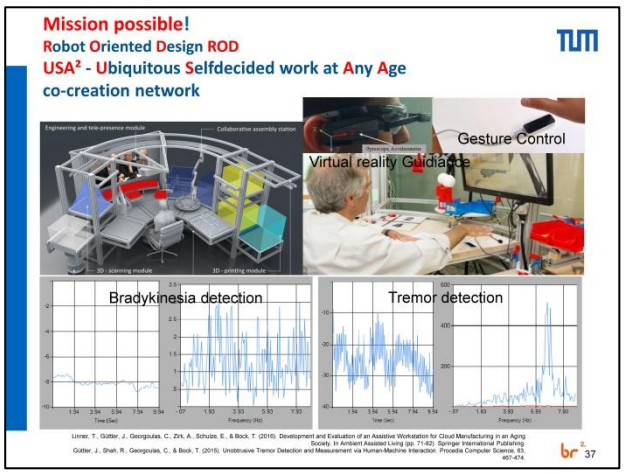


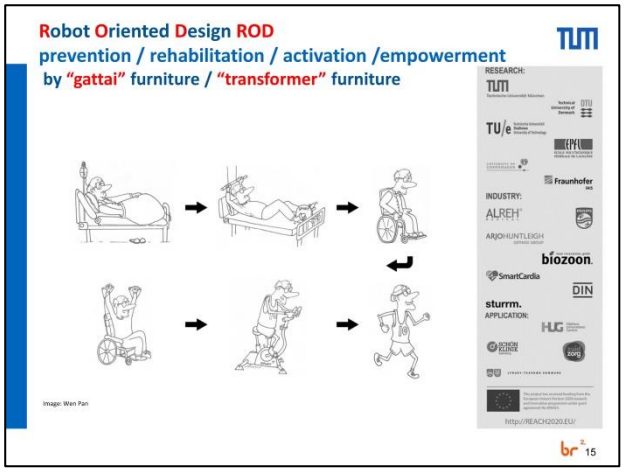
Slide 63

5. Empowering environments for satisfying inclusion

We have just finished a big project in which we coordinated 17 partners, 58 people from 6 European countries, mostly medical hospitals, care homes, health providers etc.. In this project called REACH 2020 we try to make people very active again (Slide 66). This early Manga/comics was sketched by my assistants (Slide 67). We developed a very simple activation device which is purely mechanical (Slide 68). It has to be cheap and fit anywhere, even in apartments, so this is just a mechanical activation device. We co-developed this with a Polish company in Warsaw and a hospital furniture provider from Malmoe in Sweden. Many existent rehabilitation devices use motors, but it was important that we bring down the cost and people still

have to move themselves and use their brain to move. It is similar to the HAL suits that Professor Sankai developed, but we just did it without motors. It is very low cost and can be placed in any apartment.

Slide 66



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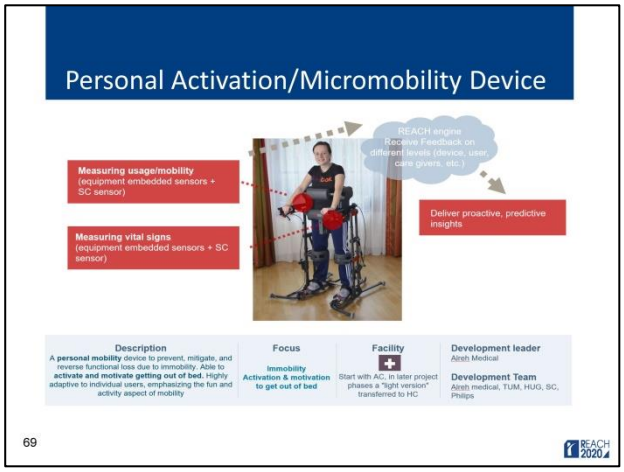


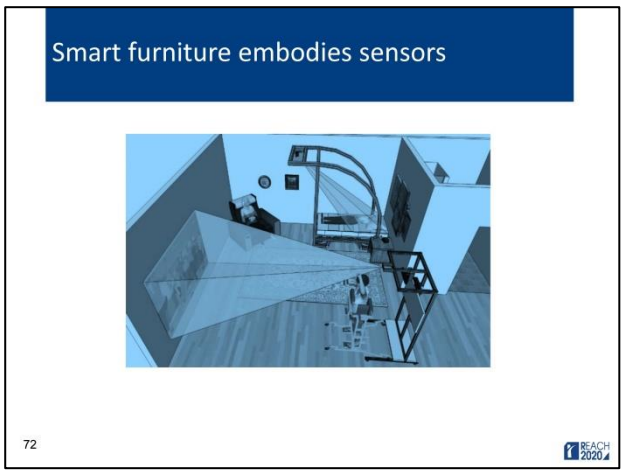
Slide 68

Old people sometimes forget to eat proper food with minerals and vitamins (Slide 69). We developed a 3D printer to consider proper nutrition of mineral and vitamin content. We can monitor the food intake. The food from the 3D printer does not look as nice as *kaiseki ryori*, but it at least has proper minerals and vitamins.

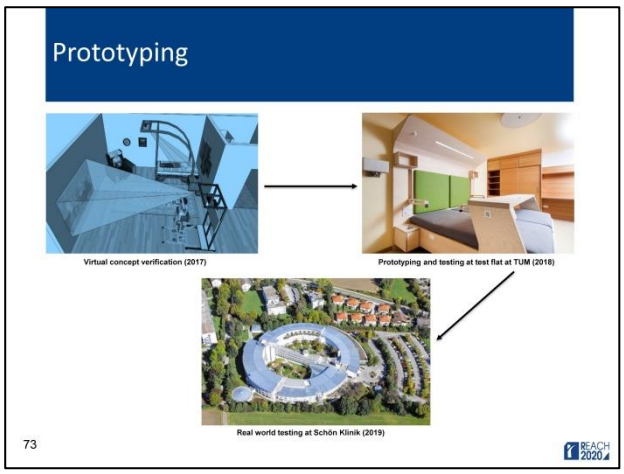
Slide 69

Entertainment and gaming is also very important (Slide 70) for social inclusion. People have to play together, for example with games, for better human interaction. We can project games and entertainment wherever, such as on the wall, on the table, or on the bed cover (Slide 71). We are now testing it in a rehabilitation hospital in the south of Munich and in other hospitals in Geneva, Eindhoven, Copenhagen, and Warsaw (Slide 72). It is a European project and so it includes many European countries.

Slide 70

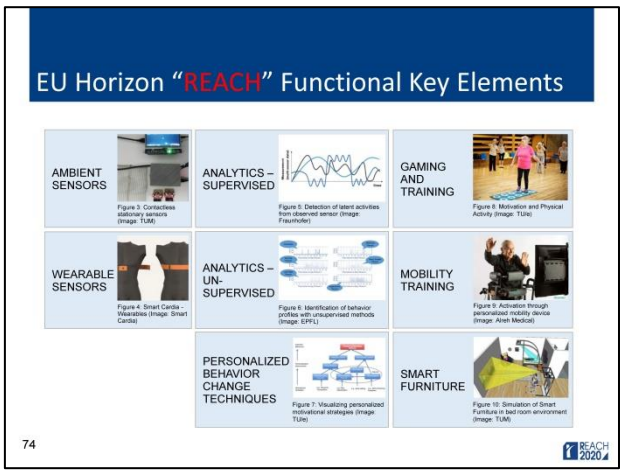


Slide 71



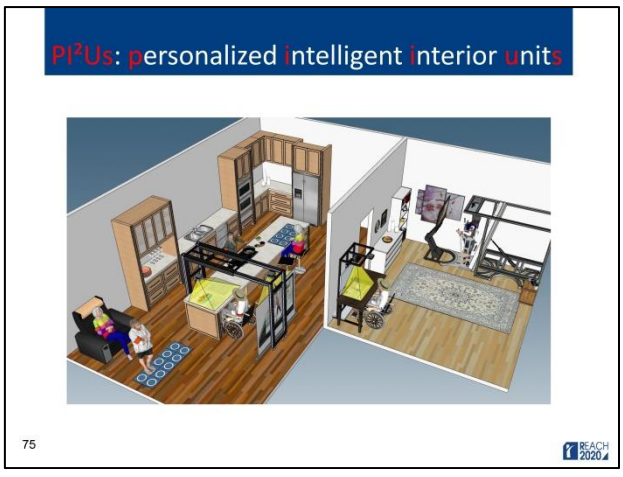
Slide 72

What I am doing is ambient sensing (Slide 73) embedded in the built environment or infrastructure that surrounds us daily. We develop new contactless sensors and also use wearable sensors. We developed these ones on our own. We fused all the sensor information and then analyzed the health state of the people so that the disease does not get worse.



Slide 73

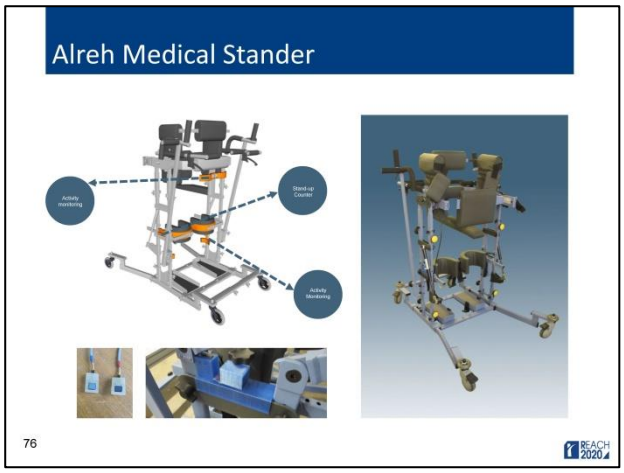
This is the whole setup (Slide 74). It can be implemented in a care home, a hospital, a home, or an activity center. It is all modularized. It can be configured for whatever you need. I think that personalization is very important because each person has different deficiencies. Therefore, we have to customize and personalize for each person. However, it would be too expensive to personalize and so our strategy is to modularize. We have little modules that we assemble for the personalized use for each person. For example, here we have modularized floor tiles for gaming. You can step on it and then the light goes on.



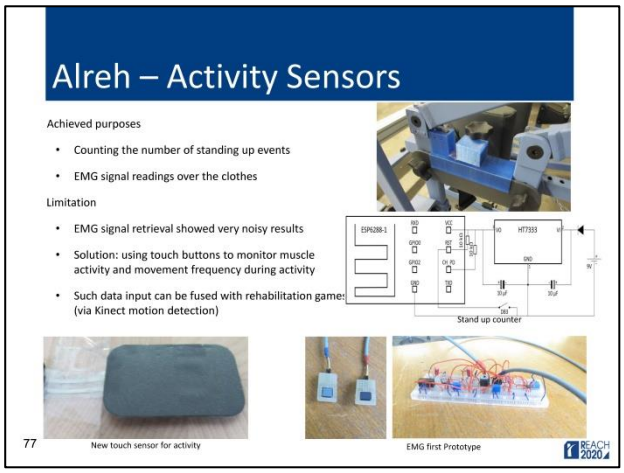
Slide 74

This activation or preventive rehabilitation device does not have motors, but has lots of sensors, so we can check the health condition while you are doing exercise (Slide 75). Here, you can see the specially built sensors in the activation device (Slide 76). Here, we have a docking port, so

you can dock it to the bed (Slide 77). It can also dock to tables such as a work table, a computer table, or a gaming table (Slide 78). You can also use it for cooking (Slide 79). You can project a recipe for cooking a dish or use it for gaming and communication etc.. You can do any kind of things. You can dock it to the bed from four sides, and the bed can also flip over to help a person up (Slide 80). We also developed a sensor that can measure through the mattress, so even when you are sleeping in the bed, we can detect a heart problem (Slide 81).



Slide 75



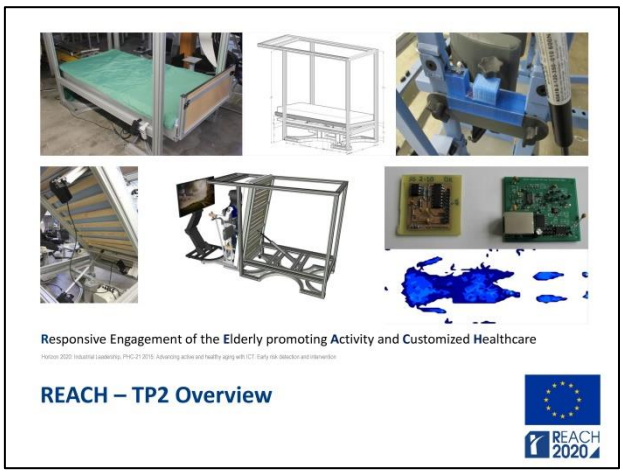
Slide 76

Slide 77

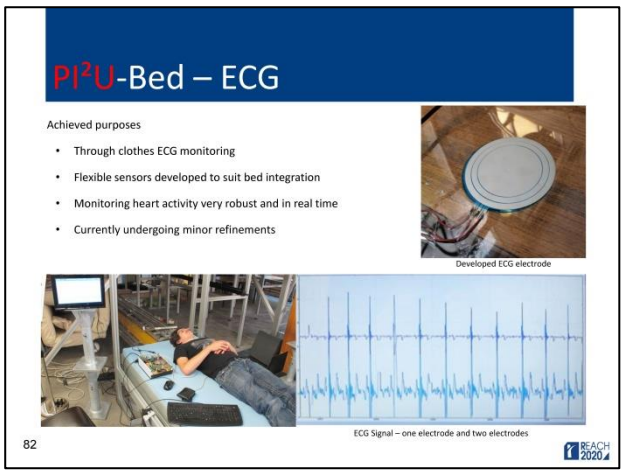
Slide 78

Slide 79

Slide 80



Slide 82

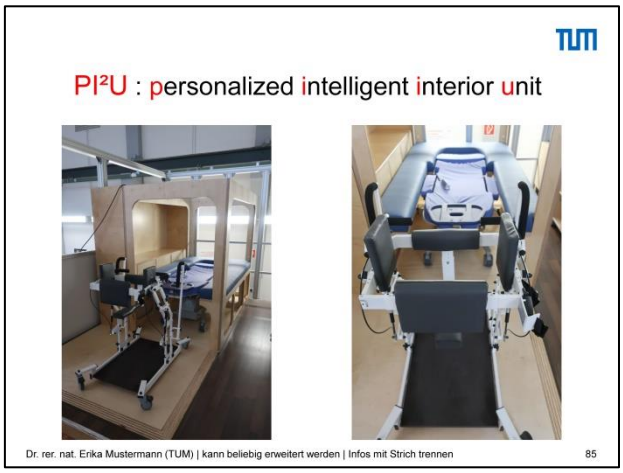


Slide 81

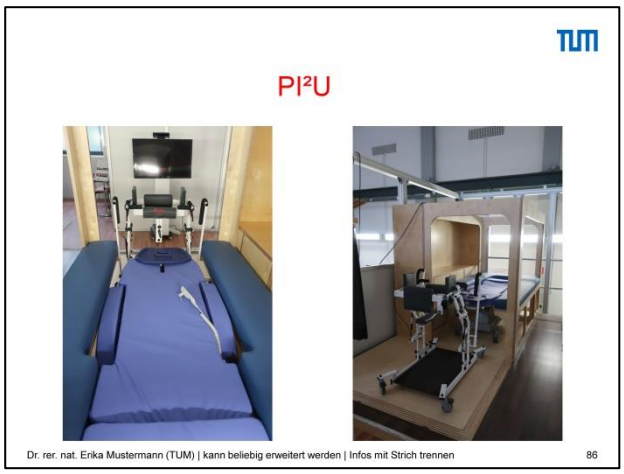
Slide 83

This shows the transformer bed how it works together (Slide 82) with the rehabilitation or preventive activation device. It lifts you up from the bed and then you can go into the activation device and do some gaming or exercise. We can also detect the pressure of the body through the mattress. Here, you can see docking devices (Slide 83). We can use it from the side to wash your hair or face and to do some computer work. Each station can dock from all four sides.

Now, it is covered with wood and so it looks better (Slides 84-85). This is the final version which is now being presented to all the partners in the European project.



Slide 84



Slide 85

You can place this activity center at home and enjoy all the four activities (Slide 86). It can be used for socializing, gaming, and entertainment. People stay active and happy, and can also communicate with others.

Slide 86

If you want to read more, the fifth volume of *Cambridge Handbooks in Construction Robotics* is about what I just presented (Slide 87). I just published it in September 2018 with Cambridge University Press and titled it *Ambient Integrated Robotics*. :

https://www.cambridge.org/core/books/ambient-integrated-robotics/C2566897BD75BCF4CC2686D295AE1FF4

You can also see my home page which is all in English.:

www.br2.ar.tum.de

The EU Horizon 2020 project REACH:

http://reach2020.eu/#

You can also check the new ISO TC 314 on Aging Societies:

https://committee.iso.org/sites/tc314/home/news.html

You can also download special issue on our EU Horizon 2020 project REACH published as special June 2020 edition at the Journal of Population Aging, Springer Edition:

https://link.springer.com/journal/12062/13/2

See my Linked In site:

https://www.linkedin.com/in/thomas-bock-5a25651/

See my ResearchGate site:

https://www.researchgate.net/profile/Thomas_Bock2

Further see some YouTube

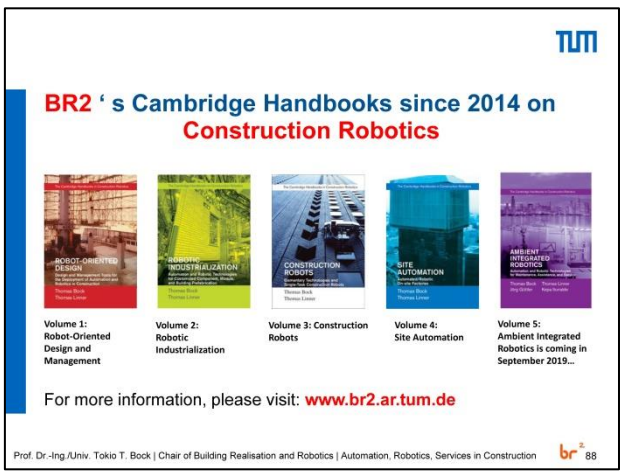
https://www.youtube.com/watch?list=PLOTXpcboneiVaZO_0lXLM6i-ND9m9TwSI&v=1g1dI9trRbg&feature=emb_logo

and a TEDx talk:

https://www.youtube.com/watch?time_continue=10&v=U5DoJ_jCt7E&feature=emb_logo

Also I start a new company with my assistants this month of July 2020 to upramp next activities till retiring from TU Munich in 2023. The company name is CREDO Robotics GmbH, "Credo" derived from Latin "I believe" stands for "Create Robot Embedded DOmotics", and "Do" stands for the "way" in Japanese.

So in future you can find out about the topic I presented today. Arigato gozaimashita. Thomas Bock.



Slide 87