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TOYS, DRONES, AND HUMANOIDS

The New Robotics Exhibition at the Deutsches Museum, Munich

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Today robots seem to be everywhere. While we have so far known them primarily from Hollywood movies, video games, science fiction novels, or industrial production halls, robots are taking over a growing number of everyday chores. These service robots are no longer separated from humans, but are located directly in our private environment. This not only awakens expectations, but also stirs up fears.

From mid-2022, the new permanent exhibition on robotics at the Deutsches Museum (Munich, Germany) has offered an opportunity to explore this discussion. This article examines the concepts underlying the new robotics exhibition with a special focus on the challenges of building up and keeping in existence the museum's collection of robots as well as the challenges of exhibiting and imparting objects from a relatively new and fast-moving field of research such as robotics in a permanent exhibition.

Robots are Coming—Are They Really?

Today everybody is talking about robots.[1] Hardly a day goes by without an article appearing in the newspapers or a new video from a technology laboratory going viral. Robots seem to be everywhere. While we have so far known them primarily from Hollywood movies[2], video games, science fiction novels, or the industrial environment of the production hall, robots are evermore conquering the private sphere.[3] So-called service robots are taking over a growing number of everyday chores—just think of robotic vacuum cleaners. More and more robots are being

1 Hampton, *Imagining Slaves and Robots*.

2 And the interest in films with robots is unbroken, as the planned releases show: From dramas like *Bios*, to *Robocalypse*, a film adaption of a novel, to horror movies *Zombies vs. Robots* or animated movies like *Pet Robots*. There seems to be something for everyone.

3 Predictions forecast a worldwide increase of service robots sales from USD 35.05 million to USD 230.26 million between 2018 and 2025. Tractica, "Robotics Market Forecasts," statista.com, accessed 1 January, 2021, https://de.statista.com/statistik/ daten/studie/870594/umfrage/umsatz-mit-servicerobotern-weltweit/#statisticContainer.

developed for the most diverse applications. These service robots are no longer separated from humans like conventional industrial robots but are located directly in our private environment. As with the industrial robots that emerged in the 1960s and often triggered worries of job losses, the emerging service robots often stir up human fears. At the same time, these robots also awake many expectations. Some fear that they might keep us as their pets, as Marvin Minsky indicates; some hope that they will make our lives easier.[4] Most likely, they will come, so the question is how will society and each individual deal with it. From Mid-2022, the new permanent exhibition on robotics at the Deutsches Museum, Munich, Germany will offer an opportunity to approach this debate. With the aid of various objects, visitors will be able to explore (service-)robotics and its various facets and dimensions not only on a technical but also on ethical, social, and cultural planes. By discovering the exhibition and its objects, they should obtain low-threshold input on the basis of which they can form their own opinion about robots.

In this article, we will focus on the museum's robotics collection, which forms the foundation of the new robotics exhibition. Then, the article will introduce the concept behind the exhibition, its underlying assumptions, and the different areas of the exhibition. It is important to note that we are not in the position to judge whether this concept exhibition could be comprehensibly implemented. Lastly, the article explores the question of how individuals deal with the conflict between conservational responsibility and the desire to show more than just static objects.

The Robotics Collection: What Do We Collect?

"The scientific object collections are the core and foundation of the Deutsches Museum,"[5] according to the recent guidelines for collection development of the museum. Since robotics is a relatively young discipline, the collection also has a rather short history. Therefore it is not surprising that robotics was not one of the forty-five original collection areas. Yet, robotics is still not an collection area today. Strictly speaking, the robots of the Deutsches Museum are located in two different collections: Industrial robots are assigned to the field of metalworking and service robots to the collection of automation technology. This results from the desire to avoid an orientation towards too short-term developments. This article will concentrate on the field of service robotics because the new permanent exhibition on robotics will focus on this kind of robot.

Although the Deutsches Museum occasionally collected few robots and

4 B. Darrach, "Meet Shaky, the first eletronic person. The fascinating and fearsome reality of a machine with a mind of its own." *Life* 20 Nov 1970, 58B–68.

5 Ulrich Kernbach, "Leitlinien zur Sammlungsentwicklung. Grundlagen – Strategie – Planung," internal paper, 2019, 4.

especially automatons previously, a dedicated approach to collecting service robots did not begin until 2005, when a separate subgroup of the automation technology collection was created. The museum began to acquire several sets of service robots from various universities and institutions that had done research in the field. Accordingly, an important part of the collection is made up of robots developed in the research context. These are more or less prototypes, which, unlike market-ready products, are not designed for durability. They often consist of a wide variety of materials like plastics and different metals and include adhesive tape, cable ties, or foam. This makes it difficult to preserve these objects, which according to ICOM (International Council of Museums) and the national association of museums, the Deutscher Museumsbund, is one of the major tasks of any museum. Another challenge is that robots from research are often "cannibalized": This means that parts from older models are incorporated into new robots. Hence, sometimes only individual parts and not the entire robot can be obtained for the collection. Finally yet importantly, scientists often actively use robots in this forward-looking field of research for a long time. For this reason, only robots that scientists do not need anymore can be included in the collection. As a result, more museums than the Deutsches Museum are finding it difficult to attract the latest specimens to their collections.

Beside the prototypes from research, the collection consists of market-ready products.

The following describes an exhibit planned by our staff to feature the museum's robot collection. As of the time of writing, the Deutsches Museum's permanent exhibit on robots has not been realized, so the authors are only able to describe their plans. In order to facilitate a description of the thought that went into planning the exhibit, it is discussed in present tense.

What Is A Robot?

The new Robotics exhibition will be the first permanent one on this topic in the Deutsches Museum. However, from November 2009 to June 2011, an interim exhibition called "ShowCase Robotics" was on display in the museum and well received by the visitors.[6] It was for this reason that the museum decided to make a permanent presentation on the subject.

As already mentioned, robots are almost omnipresent nowadays—not only physically but in people's imaginations. Everyone has heard of robots. But to design an exhibition about these artifacts, it is first helpful to define the term. On closer inspection, this seemingly simple question is not so easy to answer. There are—to exaggerate— more definitions than real-world robots. As Erico Guizzo from the

6 Deutsches Museum, *Jahresbericht* 2009, 36.

IEEE (Institute of Electrical and Electronics Engineers) puts it, "Robots are a diverse bunch . . . This diversity—in size, design, capabilities—means it's not easy to come up with a definition of what a robot is."[7] Because there are so many and diverse areas of application that have different requirements, it is difficult to come up with a universally valid definition. There is no such thing as *the* robot. Most definitions are technical and focus on the industrial use of robots. For example, the Robot Institute of America (RIA) defines a robot as a "reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."[8] This definition of a robot does not fit with autonomous vehicles, like cars or drones, or with so-called social robots such as Paro, which is used in therapy of people suffering from dementia. These robots interact with people on a social level and therefore have completely different requirements and properties than robots used in industry. The definition by the Robot Institute of America also does not do justice to, for example, walking machines, which are capable of locomotion and unlike robots, which fall under the definition of by the Robot Institute of America, are not mounted in a particular place.

Woodrow Hartzog, Professor of Law and Computer Science at Northeastern University, argued in an interview with *Vice* that he "would advise avoiding trying to define the term robot."[9] At no point in the exhibition do we try to define what a robot actually is. Rather, we stick with Joseph Engelberger, who was a famous pioneer in both industrial robotics as well as service robotics.[10] Therefore he is considered the "father of robotics." He reportedly answered the question of definition by avoiding it: "I can't define a robot, but I know one when I see one."[11] We assume that visitors have different ideas of robots, and usually these images do not have anything to do with existing robots. This is why we deliberately ask them what they think of when they hear the word "robot." Despite the semantic variety of the term, we have chosen several properties that robots should have. As mentioned above, the exhibition focuses on service robots rather than industrial ones, which also does not sharply delimit the field of application. The main characteristic of service robots is that they act in our world and in order to do this, they need sensors

7 Erico Guizzo, "What Is a Robot? Top roboticists explain their definition of robots," robots.ieee.org, accessed 21 December, 2020, https://robots.ieee.org/learn/what-is-a-robot/.

8 V. Daniel Hunt, *Industrial Robotics Handbook*, 7.

9 Jordan Pearson, "The sheer difficulty of defining what a robot is," Vice.com, accessed 22 December, 2020, https://www.vice.com/en/article/5394v5/the-sheer-difficulty-of-defining-what-a-robot-is.

10 Dittmann, "Maschinenintelligenz."

11 There is no written reference for the quotation. However, many authors refer to that sentence. Whether it originated from Engelberger can no longer be proven.

to detect their environment. Because of these sensors, it is not necessary to separate them from humans, as is the case with classic industrial robots.

Another criterion for robots in our exhibition is their embodiment. Because objects are the core of our exhibition, robots have to be physical items. This brings us to the last criteria for robots displayed in the exhibition: the ability to move and/or manipulate. In order to serve humans in their everyday lives, it is helpful for robots to be able to move around in space and/or manipulate objects. However, this criterion is the weakest. As can be seen from examples shown later on, not all robots presented in the exhibition have these capabilities.

The focus on physicality means that bots and programs that could be attributed to robotics in a semantic way are not included in the exhibition. Artificial Intelligence (AI) also appears only marginally in the exhibition. This is mainly due to the following three reasons: AI, like software in general, is difficult to exhibit because meaningful physical objects are usually missing. The relevant processes take place in the digital world and the machine or computer on which the programs run usually says nothing about these underlying processes. Although Artificial Intelligence in the form of embodied AI is a part of robotics, these robots displayed as static object and not shown running, do not different from robots not equipped with AI. Furthermore, the size of the exhibition space does not allow us to address Artificial Intelligence in the necessary depth. The final reason is that the new permanent presentation on robotics in the Deutsches Museum overlaps with numerous other exhibitions at the museum as well as branch museums, which include or will include software components.

In summary, we understand a service robot to be a physical item that has sensors, like cameras, ultrasonic or bumpers, and actuators, like wheels, legs, grippers or hands, which enable it to react to and interact with its environment. This is not a really true definition, but it served us as a useful guide in selecting topics and objects.

The Exhibition's Concept and its Areas

The new permanent exhibition on robotics covers an area of 220 square meters– about half of the basketball court. This is actually too little for this broad and, moreover, expanding field, but buildings and also museums are limited in their area. Nevertheless, we worked with the limitation and came up with nine topical areas for our exhibition. These include the basic areas "Art and Media," "History," "Research," and "Moving and Manipulating," as well as the application areas "Care and Medicine," "Household," "Edutainment," "Industry and Production," and "Extreme Tasks."

Art and Media

To start, we would like to ask: What do you think of when you hear the word "robot"? Although we as exhibition makers cannot say for sure, there is a very good chance that R2-D2 from Star Wars, the T-800 from Terminator, or some other robots known from pop culture come to your mind. Even if there is no statistical survey known, we assume that pop culture not exclusively but significantly shapes our images of robots.[12] In our modern life, we encounter a seemingly endless number of robots in all kinds of shapes and varieties in movies, video games and card games. This part of the exhibition presents action figures, stuffed animals, books, video games, and toys. The robots depicted do not exist in real life. Nevertheless, we wanted to show that various other media take up well-known robots. The presented robots simultaneously raise expectations and fears—just think of Robocop or the aforementioned T-800 from Terminator. The fictitious robots arouse expectations and fears of robots that already exist in reality or that could possibly exist in the future. Therefore, a major concern of the exhibition is to show what areas of application and robots already exist at present.

Not only the ideas about robots are results of media uses, mainly from movies. The term "robot" also comes from popular culture. After Josef Čapek created the neologism "robot", his brother, the important Czech playwright Karel Čapek, made it world famous in his play *R.U.R. (Rossum's Universal Robots)*, which premiered in 1920. The word is based on the Czech word "robotník," and can be translated as "worker."[13] The robots in *R.U.R.* hardly differed visually from humans, which sometimes caused confusion in the audience. Strictly speaking, Čapek's "robots" were Cyborgs, i.e. artificial humans with biological bases. Museum visitors can explore the question of how we will deal with robots in the future that not only look human but also behave like humans. We feature Bender from the American animated science fiction TV series *Futurama*, who steals, curses and lies. In the same vein, we include Marvin from the film *The Hitchhiker's Guide to the Galaxy*, who is afflicted with depression.

In the exhibition, we show that fiction and reality are not necessarily opposite poles by pairing two fictional robots with real-life equivalents: Astro Boy and Honda's Asimo and Baymax and the soft robots from Carnegie Mellon University. The fictional Astro Boy acting in the Japanese manga series of the same name qualifies as the spiritual inspiration of Honda's humanoid robot Asimo. Nevertheless, Astro Boy was not only formative for the scientists at Honda but for many robotics scientists all over Japan who grew up with manga.[14] At the same time, we show that

12 Dittmann, "Mensch und Roboter."

13 Capek, "The Meaning of "R.U.R."

14 Wagner, "Der Astro Boy-Diskurs."

reality also sometimes inspires fiction. For example, director Don Hall modeled the robot Baymax from the film *Big Hero 6* after real-life Carnegie Mellon University's soft robots, which Hall came across during his investigation for the film. In addition to all the fictional robots, the "Art and Media" area also features a real one. Using the guitar-playing robot Fingers from the German robot band Compressorhead as an example, we ask the visitors if or to what extent robots are capable of making art themselves.

History

In the subject area "History," we show that the idea of artificial helpers, friends and protectors is not a Hollywood invention but much older than one might think. Automatons, mechanical precursors of robots, have a very long tradition. Only the Deutsches Museum has a replica of a flute player automaton from medieval Arabia.[15] The museums's workshops created the replica especially for the exhibition based on descriptions. It can "play"a melody that is "programmed" onto a roller with pins. Linkages transmit the melody to the automaton's fingers. Air creates the tone. One of the exhibition's highlights is the so-called "Preaching Monk,"[16] an automaton from the 1560s (see figure 1). We do not know the artist who made it, nor what function the automaton had. Most likely, it is not a monk at all. Probably it served for the entertainment of the nobility and the presentation of power.

Yet the idea of the artificial servant is also much older than the technical realization of it. One example is the Golem from Jewish mythology. According to legend, the Prague Rabbi Loew created the artificial creature out of clay in the sixteenth century and brought it to life by magic.[17] In the exhibition, is a replica of the Golem from Fritz Wegener's silent film *The Golem: How He Came into the World* from 1920, in which the golem chops wood, collects water and sweeps the floor.[18] The Deutsches Museum's workshops also made this replica especially for the exhibition.

Research

In the "Research" area, we present, among other things, HERMES from the Bundeswehr University Munich. The robot was able to pick up things und put spoken everyday instructions into action. For example, it could be sent into the kitchen to fetch a cup of coffee standing on the table. If you consider that the robot dates from around 2000, it becomes clear that the exhibition does not show the very

15 Wiedemann, "Beiträge zur Geschichte der Naturwissenschaften."

16 Have a further look at Deutsches Museum Digital: https://digital.deutsches-museum.de/item/1984-18/.

17 Plank, "Golem and the Robot"; Nocks, "Golem."

18 Ledig, *Paul Wegeners Golem-Filme im Kontext fantastischer Literatur*; Davidowicz, "Vom Mythos zum Filmepos."

Figure 1. "Preaching Monk" Automaton, ca. 1560, Manufacturer: unknown. This early automaton figure is fully mechanical and performs various repetitive movements. The monk moves on wheels, while its feet imitate walking, and its arms and head move too. Of particular note are the eye and mouth movements, which are controlled by a delicate, precise mechanism in the figure's head and are particularly remarkable for the time period. (Photo: Deutsches Museum.)

latest robots. Rather, we present research areas that are (still) being researched today. For example, robots from the field of bionics or swarm robotics will also be on display. Other areas of research within robotics are locomotion and/or the ability to manipulate objects, which we will look at in the next area.

Moving and Manipulating

One criterion of service robots according to our understanding is the ability to move and/or manipulate objects. In the area "Moving and Manipulating" we show different ways of achieving this. For example, in addition to robots that move on wheels, we also display bipedal humanoid robots and robots that hop like a kangaroo or move on six legs. In terms of manipulating, in addition to the two-jaw grippers familiar from industry, we also show robotic replicas of the human hand and bionic grippers, for example modelled on an elephant trunk. We not only want to show which types exist, but also discuss the advantages and disadvantages of each of them.

In addition to these basic areas we show various application areas, and which robots are available in these.

Care and Medicine

Even though many robots in this field are still in prototype stage, the first products are already moving into patients' everyday lives. Care and medicine is one of the most controversial application areas of robotics. Robots in this field are accompanied by great expectations but also worries. In view of the expected increase in demand for nursing staff,[19] proponents cite the potential use of robots to relieve the burden on nursing staff. Critics primarily cite ethical concerns regarding the use of robots in nursing and medicine. For this reason, we devote special attention to the so-called social robots in the field of care. Like hardly any other object, the Paro robot stands for the tension within care robotics. The robot looks like a baby harp seal and is cute without a doubt. Although it looks like a stuffed animal, its job is serious: Paro is an assistance robot for the therapy of people suffering from dementia. Takanori Shibata developed Paro at the National Institute of Advanced Industrial Science and Technology (AIST) in Japan. The robot interacts with the patients by moving its head, face, eyes and fins and making sounds similar to those of a baby harp seal.[20] Paro is supposed to have an activating effect on the patients known from animal-assisted therapy. Unlike real animals, the robot cannot bite, does not cause allergic reactions (it has antiseptic fur), does not make a mess, and does not need to be fed. In the worst case, its battery is empty. For patients who have problems caring for themselves, Paro is meant to provide a low-maintenance alternative to real animals.[21] The assessment of the robot is nevertheless very ambivalent: A meta-study published in 2019 examined twenty-nine papers about Paro (written since 2000).[22] The authors showed that Paro, on the one hand, can reduce negative emotions, improve social engagement, and promote positive moods in patients. The surveys suggest negative effects, however. The risk of possible infantilization as well as dehumanization of care is pointed out. Also, the use of Paro sometimes evokes negative emotions in patients. Although Paro is explicitly designed to *complement* nursing staff, there is a fear that they will be replaced. Even if the discussion about the use of the robot Paro

19 In Germany, the number of people in need of long-term care is forecast to rise from 2.5 million in 2017 to 3.4 million in 2030 and 4.5 million in 2060. (Grunow, *Die Gesellschaft der Zukunft*, 130.)

20 A. J. Sharkey, and N. J. Wood, "The Paro seal robot. Demeaning or enabling?" Proceedings of 50th Annual Convention of the AISB. London, 2014.

21 C. J. Calo, N. Hunt-Bull, L. Lewis, and T. Metzler. "Ethical Implications of Using the Paro Robot with a Focus on Dementia Patient. Human-Robot Interaction in Elder Care." Papers from the 2011 AAAI Workshop, 20–24.

22 Hung et al., "Benefits and Barriers."

is much more complex than can be illustrated in an exhibition, one thing is clear: supporters and sceptics are discussing the use of social robots and especially the Paro robot. Despite the criticism that the Deutsches Museum focusses on the machines while disregarding other aspects of technology, we are interested in focusing on the ethical, social and cultural facets of robotics. We do not, however, want to preach. Rather, we want to show the different points of view and act as a mediator. Visitors will be confronted with critical questions in each area, meaning for visitors to form their own opinions.

Household

The area "Household", addresses the idea of the multifunctional robot servant, which is already known from the "Research" area. In contrast to the idea of a general handyman, we show robots that perform a specific task. Probably the best-known examples are robot vacuum cleaners, which are becoming increasingly popular.[23] The topic of social robots is also considered with the Somnox robot in this area. The peanut-shaped robot is designed to help people to sleep better and more healthily. In addition is—almost a curiosity—the Grillbot, which cleans barbeques. With such examples, we raise the question of whether a distinct robot is needed for each special application, and where it might be cheaper, faster or more useful to perform the task ourselves.

Edutainment

Robots are increasingly conquering not only the household but also children's rooms. Some readers may have tried their hand at programming a Lego Mindstorms robot. Children can use remote control or program robots. Other robots, like the little robot dinosaur Pleo, develop their own "personality," as announced in the manual. The robot behaves like a little baby dinosaur. Over time, depending on how you treat it and care for it, Pleo develops his behavior uniquely. To show that the Pleo robot is not a cute Dinosaur but just a machine consisting of many parts we present two objects: One Pleo with and the other without its artificial skin.

Industry and Production

Even though service robots are the focus of the museum's permanent exhibition on robotics; we decided to include an area about "Industry and Production". This is mainly because visitors expect classical industrial robots in an exhibition called *Robotics*. Just think of Joseph Engelberger's quote above; industrial robots probably come to your mind when you think of robots.

Even though we exhibit the 500 Puma from Unimate, as the advancement of

23 These cleaning robots have arrived in the low-price segment, as a mopping robot for about €25 shows.

the first classical Unimate industrial robot, the area also focuses on service robots in the context of industry and production. For example, the exhibition displays the KARIS PRO, a transport and logistics robot that autonomously transports parts through factory halls. It also features "cobots," an abbreviation of collaborative robots. These robotic arms are equipped with various sensors. This enables them to perceive their environment, react to it, and interact with humans.

This area also addresses the question how workplace will change due to robots. We chose to debate this question here because the industrial robot stands like no other technical artifact for the fear of job loss caused by machines. Although located in the area "Industry and Production," this question is of course not limited to this area, but takes the entire world of work into consideration. What jobs will no longer exist in fifty or one-hundred years? Which new jobs that do not exist today will emerge instead? Will humans have to work in the future anyway?

Extreme Tasks

The last application area in the exhibit design is "Extreme Tasks," which consists of two topics. Firstly, it includes robots that perform tasks that are dangerous for humans or work in places that are difficult or impossible for humans to access. For example, the display includes a robot for explosive ordnance disposal or inspecting sewers. Next, it addresses the topic of autonomous driving and flying with the help of two vehicles and a drone made for military reconnaissance. In this area, we want to explore the question of if and how humans relinquish control to robots. We ask where should they retain control as well as how will robotic systems influence (current and) future warfare.

Robots in Action or As Static Objects

Most of the robots discussed so far are displayed as static objects. This is primarily due to the aforementioned responsibility to preserve the objects in our collection. The museum is open from 9 a.m. to 5 p.m. more than 355 days a year. The prototypes in particular were not designed for the technical load of a museum and therefore cannot withstand continuous use. Even the collection's market-ready products hardly bear such long-term operation. The robots suffer every time they are turned on and every time they work. So the mechanical strain is great in the long term. Showing a large number of robots in actionwould require a team of specialized technicians who intervene as soon as a robot breaks down. It is particularly difficult to realize this in a permanent exhibition, which has an expected lifetime of 10 to 15 years. Instead, to give visitors an idea of what the various robots do, the display includes numerous media stations showing video footage of the objects. For this purpose, several robots are grouped together on one screen near to where they are located.

The sequences of the individual robots, which are approximately twenty to thirty seconds long, are looped without sound, which is not deemed necessary for understanding as it is mostly the noise of the robots. Furthermore, an open sound via loudspeakers is not easy to direct in such a way that other visitors are not disturbed by it. Experience shows that with the number of the museum's visitors headphones are no good, because only a few visitors can listen at the same time. In addition to the media stations showing the exhibited robots in action, there is another media station in the "Art and Media" area. This is a large screen mounted on the wall on which scenes from well-known robot films run as a loop. Here, too, we show the scenes without sound. Therefore, we chose sequences that work without sound, which of course limits the selection. Consequently, the media station is less intended to convey content than to support the thesis that our perceptions of robots are shaped by these movies and robots.

Although the contextualization of the static objects with media stations gives visitors an impression of the displayed robots, an exhibition about robotics without movement of any kind is not satisfying. One example is the peanut-shaped Somnox sleep robot in the "Household" area. This imitates the breathing movement of a sleeping person. We first considered letting visitors touch the robot for a haptic experience. However, due to hygienic concerns and with visitor numbers of more than one-million per year, we rejected the idea.[24] Movement is provided in one case by a robotic hand, located in a showcase, which changes its poise periodically. The founder of the Deutsches Museum wanted to convey science and technology by letting the visitors experience knowledge.[25] The exhibition's flute player automaton can be demonstrated. The exhibition becomes really interactive in the "Highlight Arena" and the "Demo Lab," both of which are located in the exhibition's center.

The "Demo Lab" features various demonstrations that teach visitors how a robot works. "Hands-on" and interactive stations have become increasingly popular since the late twentieth century.[26] One of the exhibit's demonstrations is about "Programming vs. Autonomy." In it, visitors can steer a small vehicle over a playing field (see figure 2).

They can either let the vehicle drive autonomously to its destination or "program" it: drive forward one field, turn right, drive forward two fields, and so on. After the start signal, selected areas move up and down arbitrarily. Where a journey was possible before, there may now be an obstacle in the car's way. With the help of the demo, the difference between the "rigid" programming, of e. g. an industrial

24 Deutsches Museum, *Jahresbericht 2018*, 118.

25 Füßl, *Oskar von Miller 1855–1934*, 311.

26 Caulton, *Hands-on Exhibitions*, 1.

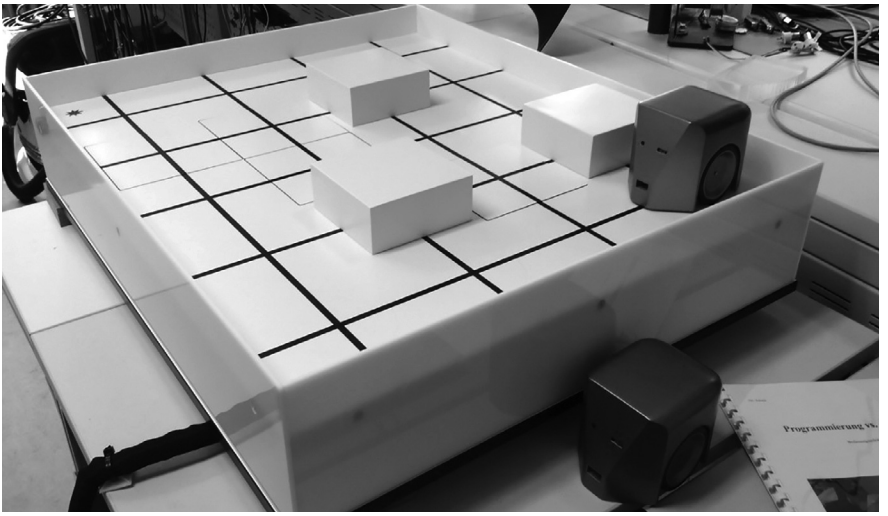

Figure 2. Trial set-up of a demonstration to be included in the exhibition: "Programming vs. Autonomy." In the demo, visitors can steer a small vehicle over a playing field. They can either let the vehicle drive autonomously to its destination or "program" the vehicle. Then the field changes. Thus the demo illustrates the difference between "rigid" programming, e. g. of an industrial robot, and the adaptable programming of service robot based on perception of the environment. (Source: Deutsches Museum.)

robot, and the adaptable programming of a service robot based on perception of the environment can be experienced.

Other demonstrations focus on how robots see and manipulate. A demonstration about robot programming, also of interest in this context, was decided against as such an offer already exists at the Deutsches Museum. The TUM Lab, an experimental laboratory of the Technical University of Munich (TUM) located in the Deutsches Museum, organizes programming courses for Lego Mindstorms.[27] However, visitors can not only try out demonstrations in the exhibition, but also interact with real robots in the "Highlight-Arena."

The "Highlight-Arena" displays, as the name suggests, the highlights of the museum's collection. For example, it features the android Saya created by Hiroshi Kobayashi from the University of Tokyo (see figure 3). Saya is designed to look humanoid and was used as a receptionist, a secretary as well as a teacher. With the help of this robot, the exhibition can address the phenomenon of the uncanny valley: the more human a robot appears, the more familiar it seems, yet if it looks too human, yet obviously behaves like a machine, the effect can be rather eerie. In the

27 Have a further look at the course offered at https://www.edu.tum.de/tumlab/kursangebot/technik/robotik/.

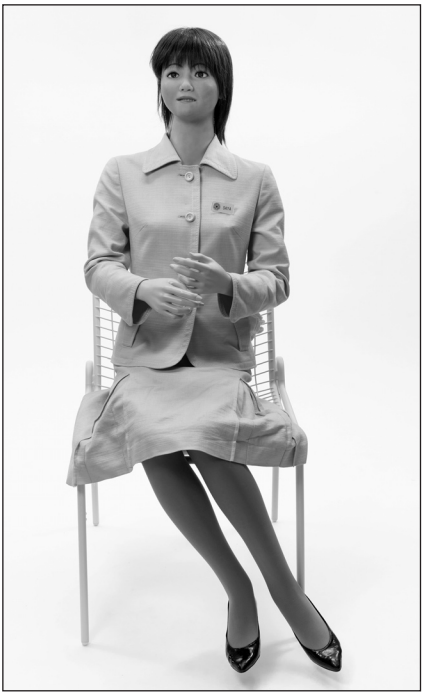

Figure 3. Saya Humanoid Robot, Hiroshi Kobayashi, University of Tokyo, 2009. Saya is a humanoid robot that was designed to be used as a receptionist, a secretary or even a teacher. (Photo: Deutsches Museum.)

"Highlight-Arena" visitors can not only see static objects but also interact with and try out two of the museum's robots. The first of these is the QTrobot. It was developed by LuxAI, a spin-off company of the University of Luxembourg. The humanoid robot is about 65 cm high and used in the therapy of children suffering from autism spectrum disorders (ASD). Visitors will be able to play different games with the robot to get a feeling of how this robot works. Of course, this is in no way to be equated with a therapy session conducted by professionals. By playing briefly with such a robot, visitors cannot form a decided opinion about the pros and cons of robotic therapy. Nevertheless, we want to give visitors at least a vague impression of dealing with a robot.

The second robot that visitors can interact with is Nao. Although the two-leg robot developed by Aldebaran Robotics was introduced in 2006, it is still very popular today. Some museums in Germany also use the robot in a variety of ways. In the new permanent exhibition, visitors will be able to control the robot themselves using gestures: if a visitor wave's his left hand, Nao also waves his left hand—the robot becomes the visitor's avatar.

Educational programs

In addition to the objects, texts, media stations and demonstrations, guided tours and other educational programs are an important part of any exhibition. These tours and programs are conducted by so-called Museum Communicators (M-Coms). These are colleagues who are in the exhibitions throughout the museum's opening hours and are available for questions and discussions. The exchange with visitors does not take place top down, but on an equal footing. The Museum Communicators conduct guided tours, demonstrations, and interactive presentations at the various exhibitions at specific times, which visitors can attend free of charge. This includes

the Science Show "Robotic," which we are developing in cooperation with the museum's branch in Nuremberg and the education department. This show is a demonstration of various robots, which, as with the exhibition, focuses on the ethical and social aspects of robotics in addition to the technical dimension. The show has a modular structure so that different focal points can be selected depending on the audience. For example, the focus can be placed on sensor technology, locomotion, or social robotics.

Conclusion

In this paper, we expounded the conceptual ideas underlying our design for the new exhibition on robotics in the Deutsches Museum. Based on the assumption that popular ideas about robots are not exclusively but significantly shaped by pop culture, the exhibition seeks to give a realistic picture of current robots. For this purpose, various robots from different research areas as well as application fields are included in the exhibit. Prospective visitors will encounter more and more of such robots in a wide variety of fields so need to be helped to figure out how society will deal with developments in robotics. In addition to the technical dimension on robotics, the public discourse must pay attention to to the ethical, cultural and social aspects of robots. The exhibit is not meant to glorify or demonize, but rather stimulate reflections by supplying information and addressing questions linked to different objects, topics and application areas. The exhibition thus serves as a low-threshold introduction to robotics. As an initial input, it (and its accompanying catalogue) should create interest in dealing with the subject matter on an ongoing basis.

Biographies

Nicolas Lange (nicolas.lange@gdke.rlp.de) worked at the Deutsches Museum in Munich between 2017 and 2021. Dr. Frank Dittmann (f.dittmann@deutsches-museum.de), still employed by the Deutsches Museum, collaborated with him to design the Robotics exhibition at the museum.

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