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White paper

The Human Touch: Robots in Healthcare

As healthcare grapples with challenges ranging from increasing patient load to maintaining safety protocols, the potential for innovative solutions becomes increasingly crucial.

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By exploring these cutting-edge developments, we aim to provide a comprehensive understanding of how robots in healthcare contribute to operational efficiency and enable a more enjoyable work environment for healthcare workers and a more patient-centred approach to service delivery.

Introduction

As healthcare grapples with challenges ranging from increasing patient load to maintaining safety protocols, the potential for innovative solutions becomes increasingly crucial. One such solution lies in the domain of robotics. Robots are already making headway in various industries and are poised to bring transformative changes to the healthcare sector. From assisting with manual tasks to facilitating complex patient rehabilitation, robots significantly reshape hospital processes, thus enhancing efficiency and safety. However, the objective is to supplement the human workforce rather than supersede them, ensuring that healthcare professionals can focus their expertise on holistic patient care.

In this paper, we delve into the rapidly expanding role of robots in healthcare, referencing the findings of the public-private non-profit partnership, Healthcare Denmark. Their work emphasises the utility of robotics in streamlining workflows, reducing work burdens, and fostering safer care environments. We further illustrate these benefits through examples of innovative robotic solutions, such as the patient rehabilitation training aid, ROBERT®, the automatic ultrasound scanner, ARTHUR, and the autonomous disinfecting UVD Robot.

About the White Paper

EDL is a leading design studio in Copenhagen that simplifies complex technologies to provide an enjoyable user experience for startups and established companies. Our extensive digital design experience spans decades, providing us with a diverse skillset to develop exceptional products.

EDL would like to thank Anton Egholm, Fernanda Nunes, Guilherme Webster, Louise Veje, Mostafa Hamzawy, and Sara Nielsen, whom we enjoyed talking to.

Please send questions to hello@edl.dk, or visit our website for more information.

Robots in Healthcare Today

The healthcare industry has long been innovating, with new technologies entering hospitals and clinics. Now, robots in healthcare are on track to be just as disruptive as robots in any other industry. Robots are already being used in hospitals worldwide and will continue to play an essential role in hospital processes and safety. The goal is never to replace healthcare personnel but to support them in everyday tasks, especially manual labour and routine chores such as transporting medicine, lifting patients, disinfecting rooms, or drawing blood. This support will free up time for more meaningful tasks and holistic patient care [1][2][3].

Healthcare Denmark, a public-private non-profit partnership regarding healthcare in Denmark, released a paper in 2022 about robots in healthcare with a national focus [2]. In this paper, they point out that the primary reason for using robots is to create safer environments, better care, and more efficient workflows for patients and healthcare workers. It is common for inefficient workflows to result in poor work environments that do not service citizens or patients. Healthcare workers can use their time and expertise more efficiently for tasks that increase their job satisfaction and give them more time to spend with patients. They also benefit from the increasing use of robots in post-hospital treatment and rehabilitation.

An example where robots help is ROBERT®, which Life Science Robotics developed to support healthcare workers with patient rehabilitation training. It enables the patient to self-train with customised exercises made by healthcare professionals who can access the training data through a monitor and advice based on the data. Because it is easy to set up and the patient can use it themselves, it frees time for other, more meaningful work, and the healthcare worker is not tasked with the lifting, sparing the caretaker [2][4].

Another featured robot is ARTHUR, an automatic ultrasound scanner from ROPCA, which Healthcare Denmark highlights for being user-friendly. The patients use ARTHUR directly, meaning no healthcare workers must be present. It guides the user through registration, placing their hand correctly on a large monitor, where ARTHUR performs the ultrasound. When tested in a clinical trial, 90% of participants said they would feel good by having the examination done by ARTHUR and that the scanning was about the same as an experienced healthcare worker [2][5].

Lastly, the final robot we would like to highlight is the UVD Robot from Blue Ocean Robotics. While COVID-19 overwhelmed hospitals, a fully autonomous robot enabled personnel to disinfect hospital rooms in minutes, creating a safer environment for staff and patients [14]. EDL was fortunate to help design the visual language around the user experience.

Room for Improvement

While development to help healthcare workers spend more time on holistic patient care improves, there is still room to become even better at helping healthcare personnel.

For example, in the US, industry studies report that nurses spend 30 per cent of their time tracking down medication, supplies, and lab results while simultaneously carrying out logistic duties [6]. A crucial time that should have gone to bedside caring for their patient. Hopefully, the situation has improved since 2011, but it shows that there still is room for improving hospital workflows.

In Denmark, **Dansk Sygeplejeråd** conducted a questionnaire with 4004 nurses that focused on similar non-nursing tasks [7]. Seventy-seven per cent acknowledged spending approximately 67 minutes on non-nursing tasks during an ordinary workday.

The most frequent tasks were cleaning up garbage (69%), other cleaning duties (50%), refilling medicine and supplies (41%) and washing dishes (40%).

According to the questionnaire, there is a correlation between doing non-nursing tasks and the felt experience of work pressure. On average, they estimate a 10 per cent increase in work pressure with nurses doing non-nursing tasks compared to nurses doing tasks they deem valuable.

There are two sides to improving the healthcare sector with robotics. First, there is the workforce, and then there are the patients. Patients are equally—and sometimes more—affected by the presence of robots.

In late 2016 PWC, the second-largest professional services network in the world, asked YouGov to survey the general public across twelve countries in Europe, the Middle East, and Africa to understand three things:

- How they felt about engaging with AI and robots in healthcare?
- Under what circumstances would they or would they not be willing to engage?
- What advantages and disadvantages were there of using AI and robots in healthcare?

They surveyed 12,000 people and found several findings concerning the use of robots [8]. It is important to note that the questions were multiple-choice. The respondents, aged 18 and above, were asked which procedures they were willing to receive from a robot and or AI, and the top-scoring procedures (30-37 per cent) were:

1. Monitor heart conditions
2. Customised advice for health and fitness
3. Take a blood sample and analyse it

The procedures receiving the lowest approval (1-9 per cent) were:

1. Pregnancy-related actions, childbirth, and monitoring hereof
2. Practices that require the robot to touch a human (e.g., set a broken bone or stitch and bandage cut wounds.)

When looking at the disadvantages of using robotics and or AI, the respondents mainly expressed concern if something unexpected happened (47 per cent), the “human touch” (38 per cent), and the lack of knowledge from the public to understand the technologies’ benefit in healthcare (30 per cent).

“The survey points to somewhat skepticism of the technologies regarding our health and highlights a damning user experience problem: People are too afraid to engage with robots because the perceived usability is seemingly too high.”

An interesting highlight is that 16% of all age groups answered: “It is too complicated for people to access and use this kind of technology.” The survey points to somewhat scepticism of the technologies regarding our health and highlights a damning user experience problem: People are too afraid to engage with robots because the perceived usability is seemingly too high.

PWC concluded: “Trust in the technology is vital for wider use and adoption; the ‘human touch’ remains a key component of the healthcare experience.” [1]

Before reaching a place where healthcare personnel can spend all their time doing meaningful work, and the general public is more optimistic about encountering robots, the robot industry still has some way to go. While there is a big focus on safety, privacy, and crushing technical challenges [1], we believe the most significant challenge currently is creating product experiences enabling humans and robots to collaborate and co-exist more seamlessly and delightfully.

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Louise Haugaard Gotfredsen, Project Leader at the Health Innovation Centre of Southern Denmark, summed it up perfectly. She spoke to Odense Robotics: “If you want to develop robot solutions that create value in the healthcare sector, you must tune in on what the users need. The analysis of user needs (…) showed that healthcare professionals walk a lot of kilometers and spend a lot of time collecting materials to care for patients in different wards (…). The expected benefit of having the robot ease this workflow is that healthcare professionals get more valuable time tending to patients.” [9]

To tackle these challenges surrounding human interaction, researchers and practitioners advocate for an alternative perspective and suggest a different way of working will be required [10][11][13][18].

Key takeaways

- Seventy-seven per cent of nurses in Denmark say they spend time on non-nursing tasks daily.
- PWC concludes that trust in robotics is vital for broader adoption.
- Louise Haugaard Gotfredsen, Health Innovation Centre of Southern Denmark, believes we must focus on the user to create value with robotics.

A Good User Experience is Good Business

We are slowly experiencing a fundamental shift in the product development of robotics software. It is maturing from purely engineering-led to a more human-centred, design-led approach.

The fundamental goal of design-led product development is to enhance the user experience by addressing the users' needs and providing the best possible product experience based on real-life insights.

Three key reasons to invest in a better UX
Focusing on the UX results in a higher acceptance rate of new robotics technology by employees, robot operators, and bystanders. Furthermore, their task completion rate increases, which leads to fewer errors and fewer support calls [10][15][16].
Developing robotics software becomes cheaper when UX leads the iterative development cycle. Early prototypes, research, and testing before coding reduce the risk of mistakes before introducing them in the final product [17][18].
It helps businesses discover new opportunities. The "Smooth Robot Project," which focused on developing robots to help the elderly, is an excellent example. Leon Bodenhagen, Associate Professor at SDU Robotics at the Maersk Mc-Kinney Møller Institute, SDU, spoke about their process: "In the SMOOTH project, we have had the end user [elderly people and nurses] at the center of the design process all along, as we quickly realised that we should start with the low-hanging fruits. In this case, automation of repetitive tasks, which take up a lot of time for nursing staff". Co-designing with their end-user, they had three use cases: laundry and garbage collection, serving fluids, and guiding people [9].

Universal Robots' Jacob Bom Madsen, a Lead Product Manager for User Interaction, says to their blog: "We test our prototypes in collaboration with our customers to ensure that the product becomes something they love and enjoy using. Whether it is a small 10-person machine shop owner or a large production engineer, it is all about bringing our customers the greatest possible success!" [19]

Key takeaways

- The primary goal is to provide the best possible user experience (UX). This helps businesses grow and maintain customers.
- An iterative process with prototypes and user research eliminates expensive mistakes later on.
- Use research to discover new business opportunities and promote business growth.

Robotics and the User Experience

People will always have an experience when they are involved in an activity. It might be anticipated, short, periodic, shared in a group, or continuously. Nonetheless, we have an experience all the time [20]. UX design is about how we affect that experience and tip the scales in our users' favour. The user experience cannot be predetermined or fully controlled, but we can influence it significantly. A positive user experience does not occur magically; it has to be systematically cared for and evaluated [10].

When developing robots for real-world use, the user experience design should be based on a thorough understanding of the intended user groups, their needs, and the usage context [10].

As the name suggests, an emerging research field called Human-Robot Interaction (HRI) concerns the human experience and how we work, play, and interact with different types of robots. It does not matter if it is industrial, professional, or personal service robots. These robots aim to help by performing a task or providing entertainment. HRI asserts that whenever an interaction between the user and the robot takes place, the interaction must be carefully considered to give the maximum value [20].

Alenljung, B., Lindblom, J., Andersson, R. & T. Ziemke [10] argue that an excellent way to evolve the field of HRI is to adopt proven research, testing, and prototyping methods from already existing areas such as Human-Computer Interaction [HCI] and UX, however, practitioners already working with robots, like robot developers, need guidance on correctly choosing and applying UX methods and approaches for addressing the interaction between humans and robots. With this in mind, there are essential differences between the traditional UX of products and services and robotic technology. In general, the difference is that, to some extent, a robot acts autonomously in its context, meaning it will make its own decisions and adjust to the circumstances, which results in many variables depending on the user, task, and context [10].

This point is cooperated by Mostafa Hamzaway, Senior User Experience Designer, INTDV, who helped design a robot called Pepper, whom we spoke to while writing: "The UX process in a robotic project changes every time, so it is hard to define. We do not have explicit methods yet in robotics.
Instead, we follow general user experience guidelines and try to emulate every human reaction with the robot to deliver the best product."

Key takeaways

- Users will have an experience—even if it is not cared for.
- Human-Robot Interaction (HRI) deals with the UX related to robots.
- Every robotic project is a new experience. Therefore it is essential to have a solid UX process.

The Path to a Good User Experience

There are several vital things to consider and pay attention to when designing robots. We have compiled a list from our experience, research papers, and interviews with other designers. It is not exhaustive but includes some of the crucial aspects of UX design in robotics [10][17][27][26].

- **Hardware:** What is technically feasible?
- **Users:** Who will use the technology, and who will experience it?
- **Security:** What scenarios do we envision, and how do we prevent them?
- **Context:** Where, when, and for how long at a time?
- **Appearance:** How does the technology look? Shape and colour; lights and sounds?
- **User interface:** Is interaction done through a physical interface, graphical interface, or voice control? Is it accessible and easy to configure and use?
- **Control:** Is it controlled with any smartphone or an included tablet? Is it voice-controlled or autonomous?
- **Research and testing:** Are we heading in the right direction?

When designing robots, there are at least two types of users to consider. The primary user group is the people who interact directly with the robots. These would be the operator, supervisor, or someone actively impacted by the robot [21]. An example with different primary users throughout the user journey is the robot ROBERT®, mentioned earlier, which helped physiotherapist and their patients in their daily training. Here the patient becomes the primary user when the training program is running, and one could argue they become the primary user with the physiotherapist when the patient is attached to ROBERT®.

The secondary user group, which we might call bystanders, can also be essential depending on the robot's functions. They are people who passively encounter the robot and do not have any "job to be done." For example, if the robot were at a hospital, other patients in a room, family members, or medical staff. BrainCorp, specialising in cleaning, moving, and inventory robots, describes why the secondary user group is equally important to them: "It is the role of UX to make sure this first experience - and every experience - with our robots is as unobtrusive as possible. Our goal is for these users to notice the clean floor or the stocked shelves the robot provides, not the robot itself. If they encounter the robot, UX ensures it will be polite and clearly show its intent when passing a shopper or negotiating to share an aisle." [15]

Trust is another essential part of the human experience with robots, as PWC also concluded in their paper [1]. People need to trust robots to collaborate with them, accept their advice, purchase them, and delegate tasks to them. Anton Egholm, a software developer at Life Science Robotics, mentioned this challenge when we spoke to him. In his experience, some physiotherapists they meet when presenting ROBERT® can be afraid and sceptical of introducing the robot into their everyday work. However, once they get accustomed, the experience changes. Anton explains how they use this initial feedback from the physiotherapist to improve the user workflow.

Building trust is highly desirable both from a business and robot engineering perspective. If we zoom in, trust in the human-robot interaction is complex. For instance, people may trust another human (or even a robot) based on evidence of reliability, competence, sincerity, or ethical integrity [10]. The key to understanding this area is managing expectations. Boris Savic, Associate Director of User Experience at Boston UX, explains to Design News: “The more familiar the task, the more ingrained the user’s expectation is of how the task should be performed. Users can have pretty sophisticated expectations that may not always be in line with the robot’s capabilities. Good UX design can help bridge that gap.” [17]

Two approaches can avoid a mismatch in expectations. Either expect to rapidly expand the robot’s capabilities, which most companies strive for, or manage expectations beforehand. The last approach requires the user to understand how the robot works with its abilities and limitations [22].

One way of managing expectations is to do initial research and get feedback early and often, with the actual users in the correct context of use. Elaheh Shahmir Shourmasti, Ricardo Colomo-Palacios, Harald Holocene, and Selina Demi propose evaluations throughout the design process [18]. This requires including users and receiving feedback on design ideas in the early stages. Early feedback provides valuable information on interaction, alternative designs, discovering obstacles, and harmful UX. Identifying this information early leads to more manageable and less time-consuming modifications of the robots’ design or interaction flow than in the later stages.

What often happens now is that this type of user research and UX design methods is either done afterwards or not at all [18][13]. An example of why this is crucial before launching a product is exemplified in a research paper by Kristina Tornbjerg, Mikael B. Skov, Anne Marie Kanstrup, and Matthias Rehm [13]. They sought to investigate how primary and secondary users received two newly deployed MiR Hook 100 TM service robots in a hospital kitchen. They interviewed 26 people, including kitchen staff, managers, and porters, about their thoughts and interactions with the robots. Moreover, they shadowed the robots and had guided tours with some of the users. The vision for deploying the robots was to ease the work of the kitchen staff by having the robots transport kitchenware and dishes. However, overall, they found that it is challenging to integrate robots in an ever-evolving work environment. They identified some fascinating challenges.

1. The kitchen received the robots because they were unreliable in transporting medics and blood. In other words, they were an afterthought.
2. Once implemented, the kitchen staff found the robots inconsistent in delivering food which meant new workflows emerged that created more complex procedures.
3. Fifty per cent of the kitchen staff (the primary users) felt they became the robots’ caretakers because they did not trust the robots would do an adequate job. They preferred to work without robots.
4. If the robot came out of range from the associated tablet or turned off, the staff lost connection with the robot and could not relocate it.
5. The hospital hallway was not wide enough to fit both a robot and a trolley used by porters (the secondary users) because the safety zone of the robot required space. In this instance, the robot would stop and play alerting sounds.

The above challenges show that robots must be carefully designed to perform a specific job. If not, we risk low user adaptation because it introduces invisible work, leading to frustration. Invisible work is minor hiccups preventing users from doing their actual job

(e.g., the robot went missing, or the primary users distrust it, so they follow along to review its actions.) Secondly, research and testing in a matching environment are necessary to discover apparent issues.

Challenges with UX Design in Robotics

As previously stated, UX design in robotics is still developing. As we write, Human-Robot Interaction (HRI) is still an immature research field, and robotics companies still do not employ enough UX designers. This lack of UX designers creates different challenges within robotics.

The obvious challenge is that a fully functional robot, with all its software and hardware, is often expensive and takes a long time to build. These parameters make it harder to prototype solutions rapidly compared to an app or building a web service. However, not impossible. 3D printers can help developers explore hardware parts, simulate social interactions, and nail ergonomics. Furthermore, digital interfaces are relatively easy to prototype and test with design software like Figma widely available. We encourage everyone to do so extensively.

Another identified issue is the lack of products to benchmark against or test. The robot industry is secretive with its designs, which hinders shared knowledge among UX practitioners [25]. Furthermore, UX goals get overlooked because it is not traditionally an activity when designing for robots. UX goals are high-level objectives or desired effects that identify essential aspects when a user interacts with a system. As a result, the effectiveness of UX benchmarking is limited [10][18].

People, in general, are still not accustomed to being around robots or interacting with them. As with other emerging technologies, this creates two separate user groups: Tech-enthusiasts who love robots (also known as early adopters) and the majority who have not been around or interacted with robots ever in their lives. It creates a large spectrum to design for, and the experience will vary depending on the targeted users [25][18].
Lastly, Guilherme Webster, UX designer at

Universal Robotics, whom we had the pleasure to talk to when writing this whitepaper. He advised new companies who wanted to invest in UX design: “If you hire someone to help you mature in the UX space, you have to give them autonomy and have their back for them to do their job. It will allow them to influence their team and show what they can do. However, if they have to justify talking to customers or testing a prototype before it goes to production, it will be a difficult journey to redefine the robots’ user experience.”

These points should not discourage anyone from starting their UX journey as a company or individual. Instead, it is supposed to show that neither UX nor robotics is uncomplicated. Consulting with and learning from designers with experience in robotics can be essential to succeed.

Key takeaways

- UX needs to be a household discipline in many robot companies. Once hired, the UX designer should be able to elevate the user experience.
- HRI is still young; There are few specialised robotic UX methods, and benchmarking other robots’ UX is too intricate and expensive.
- Implementing UX design is not a walk in the park. We recommend consulting with qualified UX designers as an initial stepping stone.

Where to Start?

We spoke with Sara Nielsen, Ph.D. Fellow at the Department of Electronic Systems, Aalborg University. She specialises in Human-Robot Interaction and has, among other areas, engaged in how companies that develop robots can adopt UX design and which strategies to utilise adoption at the individual, team, and organisational levels.

When asked about her biggest surprise regarding her research, she replied: “The coolest insight I have gained through my Ph.D. and my work with RODECA [26] is probably, that there is a willingness and expressed need, although fluctuating and sometimes only expressed by a few people, to involve users in the development of robots. But for companies where UX is not a priority, they are not in a place where they can ‘just’ use UX methods, approaches, and processes. There is simply a need for other measures which, in the long term, will hopefully make it possible for the companies to adopt these design practices.”

Our designers at EDL have suggested four different approaches, which include RODECA, co-authored by Sara. They vary depending on the willingness to invest in UX and the current development stage.

Approach 1:
Evaluate the current experience

A paper by Frijns and Schmidbauer [11] describes 24 CoBot heuristics they have defined with help from robot designers. The heuristics can assist in evaluating existing CoBots (or other robots), be used as a checklist for forming new robot experiences, or, if you are not the decision maker, as a discussion outline for where you believe your robot needs additional refinement.

Check out the complete list of heuristics on our website.

In their article, they share that robot designers highlighted two heuristics as the most important; we have added our favourite as a third heuristic:

- Human factors: Design cobot and UI with ergonomics and accessibility in mind.
- Adaptable system architecture: Enable easy software integration after hardware exchange. The system architecture should allow for adapting the system to different types of tasks and application scenarios.
- Mental model: Support the user in understanding how the system works, for instance, by providing feedback and using appropriate terminology.

While the guidelines help think about the user experience, they cannot replace working with a human-centred mindset.

Approach 2:
Contextual user insights

We always recommend observing actual humans interacting with the robot. The environment and the context will have an impact on the discoveries. To take it a step further, find allies amongst users to thoroughly test everything from autonomy, ergonomics, and tasks to onboarding of users. [21]

When doing this, there are different user research and testing approaches. For example, before starting the actual design, it could be a great idea to interview and shadow the personnel the robot is supposed to help, as seen in the Smooth Project [9]. In addition, quantitative methods like questionnaires are also valid methods for learning more about user groups.

Later in the product cycle, it can be worth experimenting with an idea without investing time and money in development [21]. A technique like Wizard of Oz could be helpful. In Wizard of Oz, a team pretends the robot has interactional skills that it does not have. An example is Savioke, who faked their robots' personality to see which type their users preferred, which saved them a ton of time [12]. When the robot is in the last stages of testing, it is a great idea to leave it in the care of users for longer. This could be quantitative with data points from the robot, e.g., does the robot break down often or has other unintended behaviour? Alternatively, qualitatively by talking with the users, how was their experience with it. For example, an earlier research paper described how the kitchen staff grew frustrated working with the robot [13]. Early insights like these could yield new designs, features, or even products.

Approach 3:
Robot design canvas

Another more comprehensive approach is to use the robot design canvas proposed by Nielsen, Ordoñez, Hansen, Skov, and Jochum [26]. The canvas is inspired by Business Model Canvas, Lean, HRI, and UX and sets out to build a shared language for designing robots. The researchers found, in collaboration with several people from the robot industry, that the framework achieves several important goals:

1. It is a structured way to design and develop robots that ensure solving real problems in the correct context.
2. Utilises skills from different backgrounds to ensure collaboration in a shared language.
3. It facilitates exploration and comparisons of market opportunities.
4. It helps to identify which skills are in-house and which are missing.

The Robot Design Canvas asks questions about specific parts of developing a new robot:

- Planning and preparing
- Context exploration
- Specify robot goals
- Design with Users and Incidentally Copresent Persons
- Develop the robot
- Robot attributes

The entire canvas with accompanying questions can are available in their article.

Approach 4:
Ask for help

Last but not least, have someone help. Hire one or more full-time product people to help facilitate and execute research, UX, and UI design.

If that proposes a challenge financially or organizationally, working with a UX agency for a few months is also a viable solution. Agencies can start working immediately, and their designers are part of a bigger team where they have their design critique sessions, team rituals, and the exchange of ideas.

Key takeaways

- UX heuristics are a great place to start when wanting to improve an existing user experience.
- Ready to move to the next level? User research should guide all product decisions.
- The safest bet: Get help from a traditional UX designer. It is even better if the UX designer can draw on their previous experience designing robots.

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