AP25: DISINFECTION ROBOTS

TYPES OF OPERATION CARRIED OUT BY THE ROBOT

Preventing the spread of germs is a constant challenge in hospitals and care homes. To stop hospital-acquired infections, considerable effort is necessary to clean and disinfect rooms as well as frequently touched objects, like handrails, desks, or elevator buttons. In addition, the growing problem of multi-resistant germs has also raised the question of which disinfection methods are best suited to kill germs efficiently without causing resistance. During an ongoing pandemic, the need for disinfection is expanded to all places that are frequented by many people, such as public transport, office buildings, or shopping malls. Thus, the COVID-19 pandemic has been a main driver for the market growth of disinfection robots. Usual means for disinfection are:

- High frequency ultraviolet light (UV-C)
- Spraying disinfection chemicals, such as hydrogen peroxide or hypochlorous acid
- Air filtering
- Mechanical wiping

These means can also be combined for better effect.

Disinfection with UV light has the advantage that the light instantly reaches all surfaces exposed to the robot. By moving around a room, furniture can be treated from all sides, e.g. in operating rooms. However, some shaded areas that cannot be reached will always remain; leaving the requirement for additional manual cleaning of critical spots once the robot has finished its job. Sprayed chemicals have a better chance of reaching obstructed areas, especially when they are sprayed from various positions as the robot moves around a room. Both UV-C and spraying disinfection cannot be applied in the presence of humans for safety reasons. Furthermore, another drawback of spraying is the time required to air the room before a person can use it again. Robots performing mechanical wiping address the problem that germs covered in dirt or grease cannot be reached by UV light or chemicals. This is especially a problem on surfaces often touched by hands, such as door handles and handrails.

Figure 3.1: Alvo Ultra V-bot – disinfection in an operating room. Image credit: Wobit.

LEVEL OF DISTRIBUTION

While robots used for disinfection played a minor role until the end of 2019, the COVID-19 pandemic has created a massive interest in robots for autonomous disinfection.

The Danish company UVD is one of the few manufacturers who already offered a disinfection robot as a product before the COVID-19 crisis. The company was founded in 2016 and won the IERA Award in 2019. Since then, the manufacturer has introduced the third generation of its robot and acquired a contract with the EU to deliver 200 robots to various hospitals in Europe.

Figure 3.2: The UV-Disinfection Robot is a disinfection robot for hospitals and manufacturing. It is used with the aim of reducing the infection rates of hospital-acquired infections and microorganisms in production. The UV-DR has a kill rate of 99.9% and moves autonomously and safely around facilities. Image credit: Blue Ocean Robotics.

Similar robot designs with UV-C light have appeared on the market since the beginning of 2020. Such robots are available from Metralabs, Otsaw, Amyrobotics, and Kompaï. Various developments of new UV disinfection robots were financed in the EU project DIH-HERO. [1]

[1] Jovanovic, Kosta, Schwier, Andrea, Matheson, EloiseXiloyannis, Michele, Rodijk-Rozeboom, Esther, Hochhausen, Nadine, Vermeulen, Brecht, Graf, Birgit, Wolf, Peter, Nawrat, Zbigniew, Escuder, Jordi, Mechelinck, Mare, Sorensen, Birgitte, Boscolo, Paola Roberta, Obach, Michael, Tognarelli, Selene, Jankovic, Milica, Leroux, Christophe, Ferrigno, Giancarlo, Siepel, Francoise J., Stramigioli, Stefano: Digital Innovation Hubs in Health-Care Robotics Fighting COVID-19: Novel Support for Patients and Health-Care Workers Across Europe. In: IEEE Robotics & Automation Magazine. - Piscataway, NJ, USA: IEEE. ISSN: 1070-9932 - 28 (2021), no. 1, S. 40-47.

Figure 3.3: Since March 2021, the French company Kompaï has also been offering a disinfection robot with UV-C light. Image credit: Kompaï Robotics.

An important aspect of the use of such robots is the fact that some of them are approved only for local markets, e.g. for some Asian countries.

New designs, e.g. from UVD and Advanced Intelligent Systems, also address human safety by using infrared sensors to detect people in the environment and to switch off the UV light. To treat hotspots with UV light when people are present, F&P Robotics has developed an attachment for the manipulator of its mobile robot Lio, which positions UV lights around a door handle while shielding them to the outside. OTSAW offers a mobile robot with two horizontal beams containing UV lights that can move through the aisle of an aircraft while disinfecting the seats to its left and right.

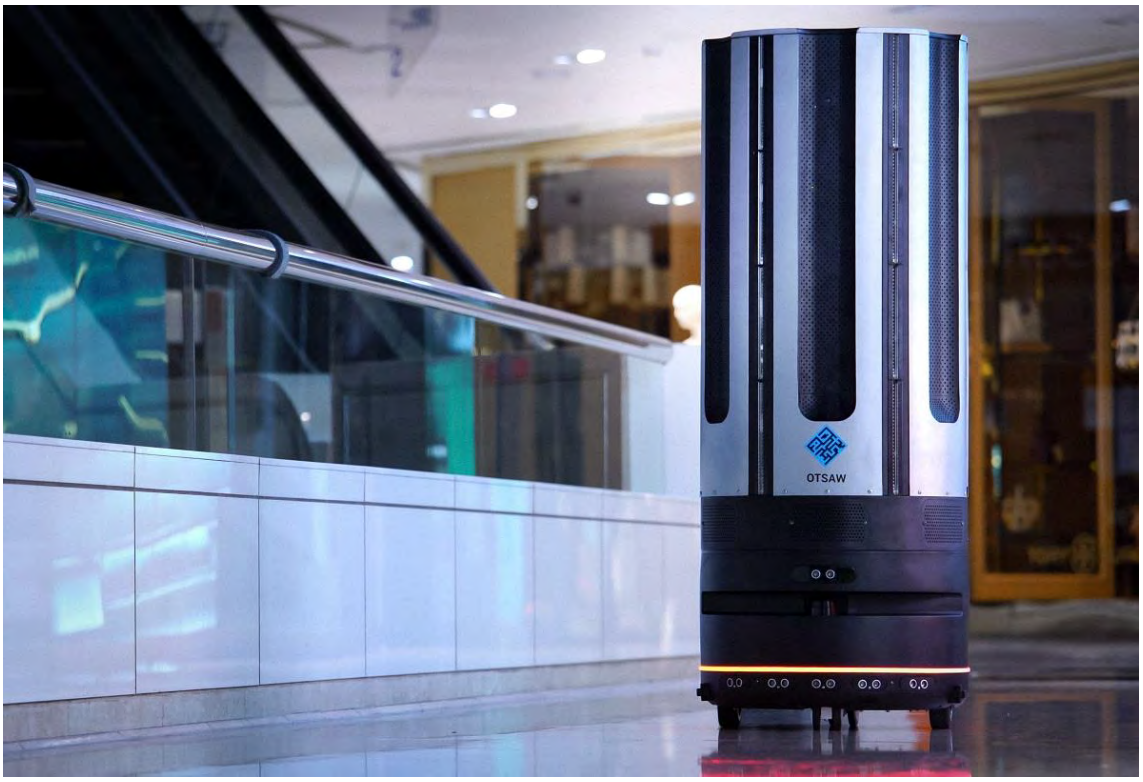

Figure 3.4: O-RX is a UV-C LED autonomous disinfecting robot with a disinfection rate of 99.999% at 2.5 meters. Image credit: OTSAW Digital.

Robots for spraying disinfection chemicals have been introduced, e.g., by Cyberdyne, Fybots, iClean, and SMP Robotics. Some robots also offer a combination of disinfection methods, such as the combination of UV-C light and spraying (e.g. Keenon). In addition to UV-C disinfection, a robot from Amyrobotics sucks air in through its structure and leads it through a filter. Some manufacturers of floor scrubbing robots have added an UV-C light source (Nilfisk, Aziobot) or an additional tank with a chlorine dioxide solution (Adlatus) to their machines to improve the cleaning result. Together with the mechanical removal of dirt, a good disinfection result can be expected in these cases.

Recent research projects have investigated the precise disinfection of frequently touched objects, based on detecting, e.g., door handles and switches using computer vision.[2] This also includes the use of a building information model (BIM) to determine object positions.[3] Furthermore, a combination of different disinfection means with mechanical wiping was investigated.

In the DeKonBot project, Fraunhofer IPA has developed the prototype of a disinfection robot that automatically recognizes surfaces to be cleaned, specifically door handles, door knobs, light switches, and elevator buttons, and then cleans them with its cleaning pads attached to the robot arm, which are wetted with disinfectant[4]. By following and automating the legally

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[2] Research Project MobDi: https://www.mobdi-projekt.de/en.html.

[3] Research Project Balto: https://nachrichten.idw-online.de/2021/05/03/disinfection-robot-value-created-by-linking-up-to-building-data/.

[4] www.ipa.fraunhofer.de/dekonbot

prescribed procedure for surface disinfection, the robot has the potential to relieve the burden on nursing or cleaning staff. The DeKonBot 2 robot is more compact, more flexible and closer to the product than its predecessor. With its cleaning brushes, the robot removes dirt from the surfaces to be cleaned and simultaneously applies disinfectant to the entire area. Currently, another new cleaning tool is being integrated into the robot that performs cleaning and disinfection - as is customary in hospitals - with the help of microfiber cloths and can also change them autonomously after use. The robot will also be able to disinfect other surfaces in the hospital, such as handrails, tables, and chairs. The project is also looking at the independent opening of doors, so that in the long term the robot will also be active in treatment rooms when they are not being used at night.

Figure 3.5: Using its cleaning brushes, DeKonBot 2 removes coarse dirt from door handles and comprehensively applies the disinfection fluid. Image credit: Fraunhofer IPA.

Some companies are also already working on 3D cleaning, i.e. cleaning surfaces above the floor. The robot from Jingwu uses a robot arm to pick up various cleaning devices such as a brush, a mop, or a squeegee and use them to clean mirrors, sinks, toilets, and floors in bathrooms. Somatic also addresses the task of cleaning bathrooms, using a combination of spraying and squeegeeing the surfaces.

At the start of the COVID-19 pandemic, many companies quickly adapted existing robot platforms to other tasks (e.g. autonomous mobile robots (AMR) for transport) and equipped them with a means for disinfection. Quite often, this was done to meet the desperate demands of the healthcare sector and governments for tools to fight the pandemic. Today, many of these "quick and dirty" solutions have vanished again. On the other hand, disinfection robots particularly designed for that purpose have become a permanent addition to the portfolios of many robot companies. This indicates that the robots seem to have proven themselves, and further need for such robots in the "new normal" is expected.

COST-BENEFIT-CONSIDERATIONS AND MARKETING CHALLENGES

Disinfection robots have the advantage that human cleaners do not have to enter contaminated areas. In addition, robots can easily withstand strong cleaning agents and are immune to the effects of ultraviolet light, thus allowing continuous operation also in confined spaces. Furthermore, robots allow more frequent disinfection than would be possible with cleaning personnel, while at the same time providing reliable documentation and avoidance of human error.

Disinfection robots have a high potential for cost reduction if they are used in settings that maximize their productivity, for example when large, open areas can be disinfected without frequent human intervention. Similar to other cleaning tasks, the robots provide a possibility to overcome the shortage of personnel.

EXPERT'S VIEW

INTERVIEW WITH UVD ROBOTS

Company:	UVD Robots (part of Blue Ocean Robotics), Odense, Denmark
No. of employees:	11-50
Products:	Disinfection Robot
Interview partners:	Claus Risager (founder and CSO)
Date:	April 20, 2023

Why did you choose to develop disinfection robots?

Our story goes back to 2014, nine years ago, when Professor Kolmos of the local University Hospital in Denmark was in the media talking about patients dying from microorganisms, which were resistant to antibiotics, and that this problem was growing. I knew that some companies were working with UV light to kill or to deactivate microorganisms. But the problem was that if microorganisms are not hit directly by the light or are too far away, they are not deactivated. So logically, if you could move around with the light and expose the surfaces to the right amount of light, it would be very effective.

So, I had the idea of using a robot to do this task. When combining this light system with an autonomous robot, we adapted everything to make sure it can sense the environment, understand the multitude of objects and surfaces, and be effortlessly programmed by members of staff, who simply need to inform it about the presence of pathogens in the room. This allows the robot to adjust its path and the duration of light exposure accordingly.

What was the most impactful decision for your product development?

There are a lot of different things that turned out to be really important. The most important part of it all lies in our collaboration with Professor Kolmos. Through our partnership with him and his team, we received invaluable feedback that not only validated many of our ideas but also guided us toward the further development of others. It was very, very important to end up with a robot that was easy to use and really did the job properly. Putting the users and the experts from the hospital at the heart of the overall development was the best and most important decision we made.

What are the biggest hurdles in terms of bringing your robots to the market?

During the initial stages, one surprising challenge we encountered was the integration of our high performance robot into daily workflows and ensuring its ease of use on a daily basis. As such, we needed to change the user interface several times and perform continuous upgrades. Ensuring seamless interaction between users, their instructions, the robot and its feedback to the users, was a major challenge.

Another notable aspect is that members of the cleaning staff often lack sufficient technical knowledge about microorganisms and disinfection . Therefore, it must be possible to operate the robot without any real understanding of these topics.

From an internal perspective, our origins may lie in robotics, but we have evolved beyond being merely a robot company. Today, we are just as much an infection prevention company with many experts in microbiology, who know how hospitals work and how services are provided. Due to the lack of relevant distributors for this market segment, we actually dealt directly with the hospitals in the beginning. So, you start out as a roboticist and end up as a specialist in a very small part of the world.

Looking into the future, what are the biggest challenges ahead for your customers?

I think one of the challenges they face is that the number of multi-resistant microorganisms, some of which pose significant difficulties in their elimination from the environment. For example, this problem is especially prominent when dealing with microorganisms that produce a biofilm. This means they cannot be deactivated with UVC light or chemicals alone. Thus, we spent a lot of time developing solutions that combine chemicals and UVC light, where we first change the structure of the biofilm so that the UVC light can penetrate it. While it is possible to deactivate these kinds of microorganisms, reaching that point can be relatively complicated.

How are you planning to further develop your products to tackle these challenges?

The key thing for our progress lies in enhancing the intelligence of the robots, enabling us to tailor their disinfection capabilities to target, for example, specific pathogens, regardless of whether they are in a spore or live microorganism state. We already have customers where our robots are connected to the hospital system. For instance, after an infected patient leaves the hospital, we are informed about the patient's infection and the robot then uses this information to adjust its process correspondingly.

If you can prevent a patient from being infected, it frees up a bed for 20.6 days. In 20.6 days, you can admit 4.6 new patients.

PRODUCERS

Addverb Technologies, Advanced Intelligent Systems, Aeolus Robotics, Agora Robotics, Aitheon, Akara Robotics, Amyrobotics, Anpei, Asimov, Ava Robotics, Build with Robots, Candroid Robotics Corporation, Casun, Chuangze Intelligent Robot, Co-Robotics, DF Automation & Robotics, Follow Inspiration, Fybots, Guandong Unipin Medical Technology, Guangdong Jaten Robot & Automation, Hyundai Robotics, ICA, iClean, Infocom, Jabil - Badger Technologies, Janyu Technologies, Kompaï Robotics, Loop Robots, Luvozo PBC, MetraLabs, Milvus Robotics, Nevoa, Nilfisk-Advance, OhmniLabs, Otsaw Digital, PalNPaul, PBA, Peanut Robotics, Potenit, Robotise, Sesto, Shanghai Keenon Intelligent Technology, Shark Robotics, Shenzhen Guoli Intelligent Technology Co. LTD, Shenzhen Sunson Tech Co, ShenZhen

Wellwit Robotics, Sherpa Mobile Robotics, Smart Robotics, Smart Technology SA (Smarlogy), SoftBank Robotics, Somatic, Spring Mobility, Techmetics Robotics, Tru-D, UBT Robot, UVD Robots, Vedroid, Vtrac Robotics, Zhejiang Blue Point Robotics