Interactive Human and Machine: Service Robots Cooperating with Humans in the Lab

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Multifunctional assistant robots interacting with humans previously belonged to the realm of science fiction but not for much longer. In the joint project LISA funded by the BMBF, the Fraunhofer IFF is collaborating with well-known partners to develop a service robot suitable for everyday use in the life science sector. It reacts to speech, navigates fully autonomously and is extremely flexible. This high-tech system makes direct teamwork between robots and humans practicable and meets the stringent safety requirements for the first time.

Fantasy lets everything appear quite simple: White service robots assiduously zip up and down a research institute's corridors. Small service units unwaveringly circle researchers and their guests, always on the lookout for a favor they can do for them, while their humanoid-looking sidekicks at the door patiently wait to help visitors into their coats. Naturally, a mobile security system is standing outside. It automatically scans the

access rights of everyone entering the building before allowing them to pass. As already said, that is only how it is in fantasy.

Actually, robots have come to assist humans in many needs, yet so far entirely differently than science fiction authors imagine. For instance, industrial robots have been successfully performing their services on factory floors for years. They take over a wide variety of tasks they can complete far better, more precisely and more reliably than humans. As subsystems, they inconspicuously perform their work in our computerized environment every day. Of late, they even clumsily roll around our feet as comical vacuum automatons or they amuse us as dancing dwarves in astronaut outfits in presentations at Japanese trade shows.

However, we still don't have a genuinely multifunctional, interactive robot for everyday use, which, equipped with a manipulator, freely moves in human surroundings and autonomously performs its services. In the past, such approaches have repeatedly failed to be commercially successful because the systems' were insufficiently suited to everyday routines, had limited functionality or safety and had a negative cost-benefit ratio.

So that this does not always remain so, as coordinator and project partner, the Fraunhofer IFF is collaborating with well-known business and industry partners in the joint project LISA. The consortium is pursuing the development of an advanced, interacting service robot for the life science sector.

It will take over routine and transport tasks in research labs and independently load the different measurement and test stations. In addition, it will be able to monitor the frequently very tightly scheduled test procedures, inform staff of problematic situations or intervene itself. All the while, the robot will intensively interact with the human staff with which it completely shares its work area.

The utility of such a system in the life science sector is indisputable.

A preponderant share of work in biotechnological and pharmaceutical research still has to be performed manually, specifically the preparation of tests and loading of certain stations, e.g. incubators, microscopes, autoclaves and pipetting stations. Until now, lab technicians' continual need of equipment and stations for new tests (and variable test procedures) stood in the way of automation. The use of assistant systems enables flexibly interlinking stations. This produces "virtual" production lines while completely retaining the functions for normal lab operation. New stations (instruments, etc.) can easily be integrated in operation without having to retrofit or expensively upgrade and integrate a stationary automated station. Moreover, given lab technicians' frequent handling of hazardous substances, assistant systems are ideal for such work and transport (even in cold rooms and safety zones and labs). Along with reducing work for staff that is harmful or critical to health, the use of assistant robots minimizes the risk of contaminated specimens and improves sterility.

Above all, flexibility, intuitive operability and safety are crucial to the acceptance of a mobile and autonomous assistant robot so intensively integrated in the rhythm of a lab staff's work. Hence, these aspects are particular priorities during its development.

For these reasons, great effort was made to select the simplest variant for user navigation, which would not prove to be a needless hindrance in a lab's everyday business. Previous assistant systems were typically too complicated to use and often required knowledge of programming to break in the system or issue it commands. Hence, the choice fell on natural speech input and output as well as a display with intuitive user navigation. Staff uses it to easily communicate with the assistant robot in complete sentences, while it addresses its human colleagues the same way.

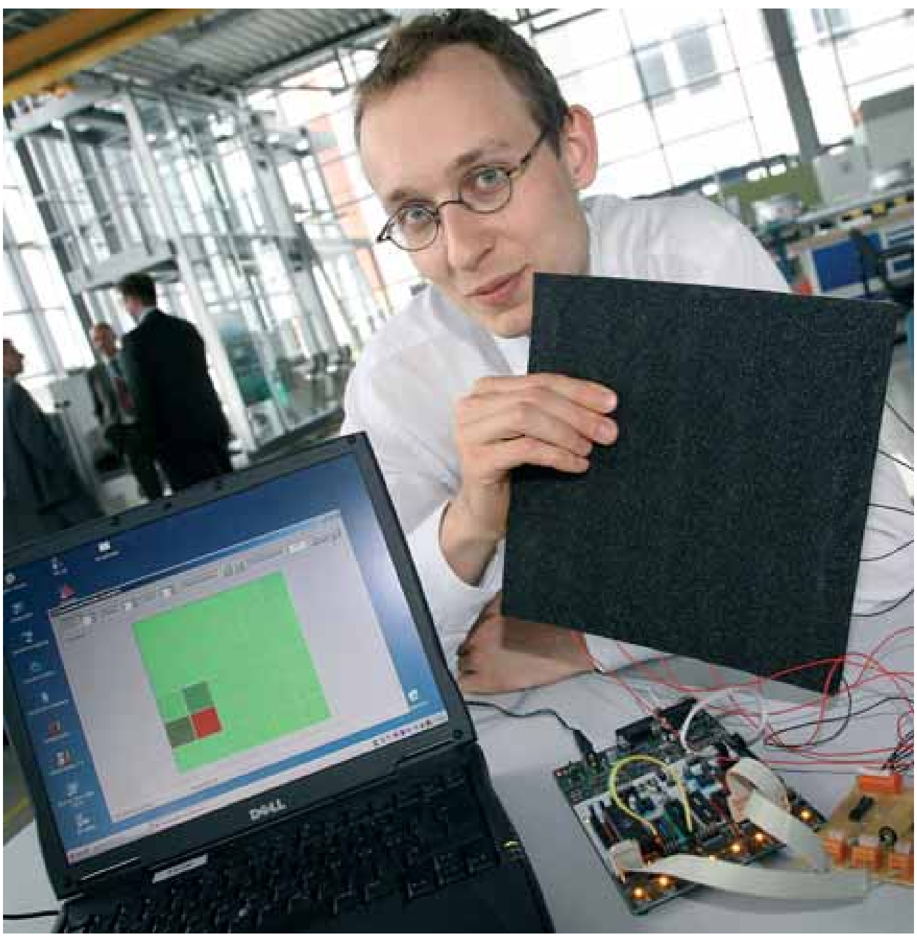
Should the system not clearly understand, it asks a specific question.

Other tasks are allocated to the display by entering commands. Thus, it also visualizes the system's state and operations. Moreover, it assumes an important function in the navigation and the allocation of its work areas before the first use of the robot.

Similar to humans, it navigates by first of all orienting itself in space and continuously correlating its position with the recorded spatial data. To do so, an integrated 3-D laser scanner models the environment in three dimensions. In turn, the information generated is visualized and output on the display. This is the basis for allocating its future work areas and the particular tasks to be completed.

Later, analysis of 2-D laser scanner data, a combined 2-D and 3-D camera system and highly sensitive collision detection sensors orient the robot in space.

Since the assistant system is mounted on a mobile platform and moves freely when in use, particular attention was paid to safety requirements. Their fulfillment is a fundamental prerequisite to the robot's use as intended. This not only pertains to protecting lab staff from being pinned or hit by the mobile platform and the manipulator but also preventing small glass bottles of chemicals or other lab utensils from being knocked over. Hence, an extensive safety sensor system is integrated in the assistant system.



Artificial skin for LISA. Markus Fritzsche developed a tactile, i.e. pressure-sensitive, surface.
Photo: Viktoria Kühne

Developing the manipulator's inherent safety, i.e. the robot's action arm, was particularly complicated. This facilitates its typical handling functions. It is outfitted with various collision detection and avoidance systems so that its movements neither harm humans nor materials. It was furnished with a "tactile skin" - one of the Fraunhofer IFF's own developments. This is a pressure-sensitive surface that precisely informs the system where and how strongly there is contact. It is an extremely elegant and innovative solution to a special problem, which will enjoy further application.

What would happen though if, despite every measure, the robot were unable to avoid a collision? In that case, its optimized engineering and the actuator selected and designed ensure damage is prevented. The kinetic energy generated is so low that even contact cannot injure an individual.

The project's prospects for success have been assessed as exceedingly positive. Biotechnology is one of the key technologies of the twenty-first century with corresponding significance for the economy. While methods to increase throughput exist for a large number of life science research enterprises, these commercial approaches are however not yet implementable. Their procedures and test series often vary widely and frequently must be rapidly adapted to current test results. The use of assistant systems is far more expedient for such firms than other automated systems or strategies to increase throughput and effectiveness. Their autonomous and highly flexible use in time and space makes these systems particularly efficient, frees lab technicians from relatively unproductive transport tasks and makes lab work possible around the clock.

The collision detection and avoidance system has already been registered for a patent. Markus Fritzsche and project manager Dr. Norbert Elkmann presented it to the professional world for the first time at the 11th IFF Science Days. Photo: Viktoria Kühne

In addition, it relieves staff from work harmful to health and ensures tests are conducted continuously and reproducibly. It promises optimal conditions to adhere to scheduled times in test procedures and potential for flexible and efficient applications - from single tests to high throughput operation. Moreover, it does so with the same lab layout and improved lab conditions for sterility and avoidance of contamination.

Thus, practical use of a first generation interactive assistant robot is more than probable in the foreseeable future. Its easy user navigation and incorporation of all safety regulations make it one of the first complex interactive robot systems that freely move in humans' immediate environment and cooperates with them. What is more, not only its positive cost-benefit ratio make it cost effective. The experiences from its development and use will additionally benefit applications in other domains. Thus, its development is only the first step to further generations of robot systems that we will surely soon encounter in everyday life.

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