Medical technology

The operating room of the future: minimally invasive and future-oriented intervention techniques

Being able to diagnose and treat tumour patients in just a few hours is just one of the many promising goals of the Fraunhofer Project Group for Automation in Medicine and Biotechnology (PAMB). The overall goal of the Intervention and Therapy research group is to take innovative technologies for diagnostic and therapeutic interventions from laboratory development to prototype production for use in clinical trials. Such technologies could range from minimally invasive instruments, medical robots to computer-controlled manipulators and implants.

The Project Group for Automation in Medicine and Biotechnology (PAMB) was co-founded by the Baden-Württemberg government and the Fraunhofer Society in 2011 under the leadership of Prof. Dr.-Ing. Jan Stallkamp from the Medical Faculty Mannheim at the University of Heidelberg. The aim was to exploit the potential for automation in medicine and technology. This is the first project group that is specifically focused on the area of life sciences automation while "offering development services in a clinical university setting where the core competences of research institutions, clinics, SMEs and start-ups come together," says Stallkamp.

Automation techniques in the field of medicine are Stallkamp's playground. Stallkamp studied mechanical engineering at Aachen University of Applied Sciences and his doctoral thesis dealt with optical 3D measurement methods for navigation in the robot-assisted field of minimally invasive surgery. In 1998, he became director of the Competence Centre for Medical Technology at the Fraunhofer IPA in Stuttgart, and in 2014 he became head of the PAMB in Mannheim and professor of automation in medicine and biotechnology.

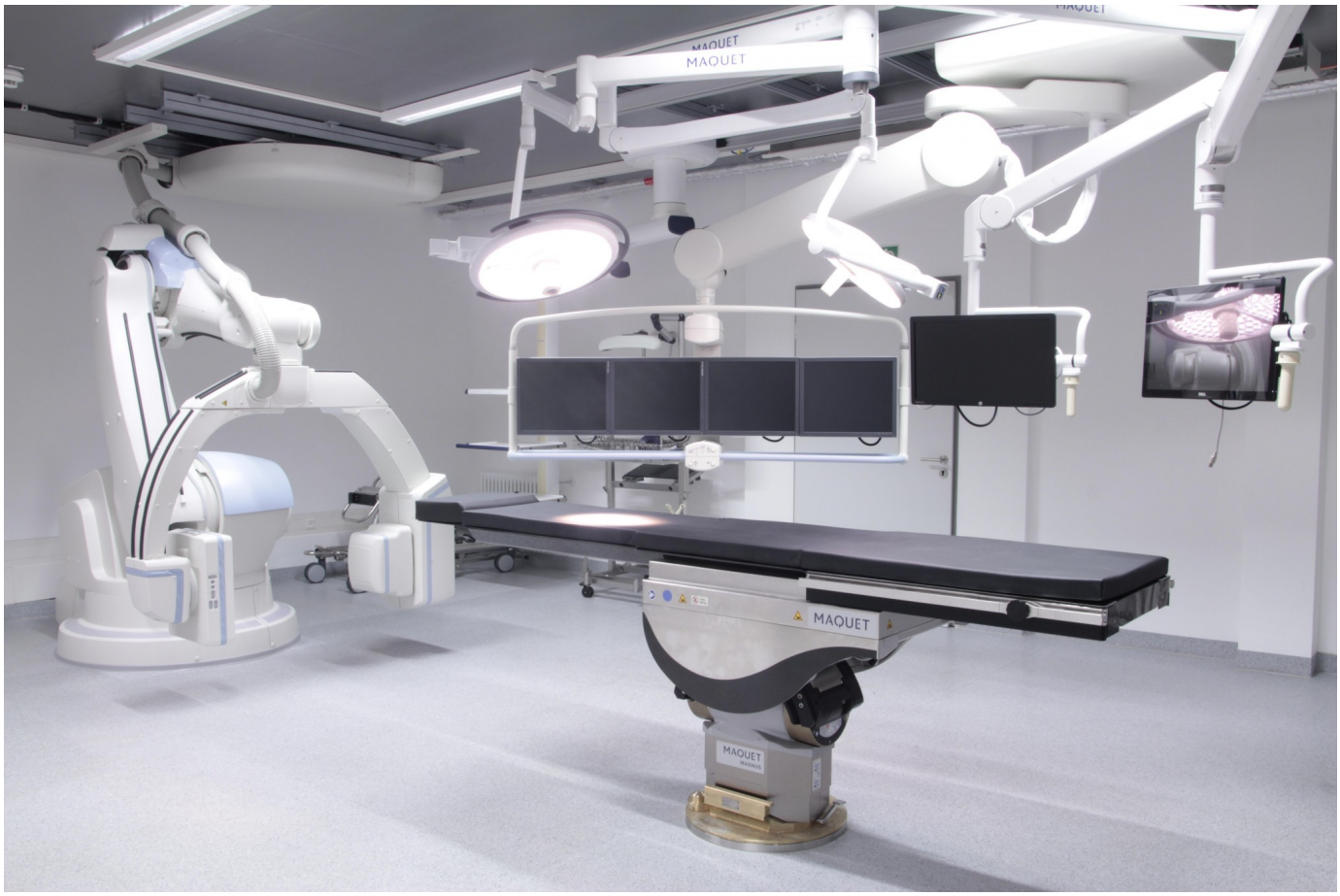
In March 2015, the project group moved into CUBEX^{41}, the research incubator for start-ups in the field of medical technology on the

Prof. Dr.-Ing. Jan Stallkamp develops automation systems and future-oriented surgical intervention techniques. © Project Group for Automation in Medicine and Biotechnology (PAMB)

Mannheim University Hospital campus. CUBEX[41] is funded by the European Union, the Baden-Württemberg government and the city of Mannheim and aims to bring together hospitals, researchers, institutions and start-ups. Stallkamp highlights the successful cooperation between industry and hospital: “Thanks to the close cooperation between the industry and the Heidelberg University Medical Faculty Mannheim, we are able to conduct pretests for numerous developments and bring customers into contact with medical doctors and scientists, thus ensuring maximum customer benefit and reducing development risks.”

Automation technology has long been an integral part of biotechnology. Automated laboratory systems advance research and development efficiently and quickly, and deliver valid results. In the field of medicine, comprehensive automation processes and multidisciplinary techniques open up many new possibilities. "The PAMB project group at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA brings together an interdisciplinary team of 37 scientists and doctors who are able to come up with innovative solutions, including the mechanical design of systems, the development of electrical circuits and control algorithms used in intervention and therapy systems,” says Stallkamp who is clearly excited about the broad range of future-oriented possibilities.

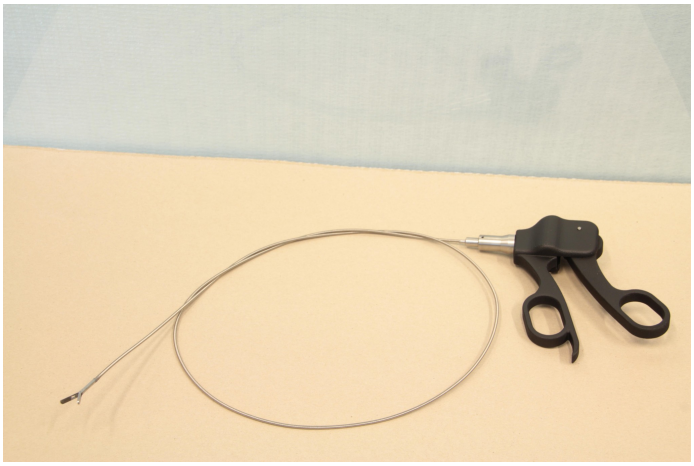
“Automation systems in the medical field must not be seen as ‘metal nurses’, but as a huge potential. Our focus is always on patients,” says the head of the PAMB. The researchers hope to come up with techniques that will enable cancer and infectious diseases to be identified more quickly than before and make treatment more efficient. The conditions for doing so are quite good – the research campus has many laboratories (for bioprocess, measurement and control technology) as well as an innovative, cutting-edge operating room.



Experimental operation room equipped with mobile X-ray device, monitors and operating table to which the intervention assistant can be moved.

Those who have the opportunity to enter this experimental operating room will immediately be able to identify its interdisciplinary nature: it is a big room with an operating table with lamps and all the necessary devices as well as a mobile X-ray device, apparatuses with high-tech control panels, robotic arms and ultramodern monitors. “Researchers and customers can test new systems here and let ideas mature in clinical settings.” In addition to this operating room, which is exclusively used for research and development, a second operating room is used for actual surgical interventions, so that the know-how can be directly transferred into clinical settings. “We want to make patient treatment gentler and faster and the work of the operating surgeon easier.” But how do PAMB’s promising ideas find their way into real life situations?

Medical progress through better, more targeted methods and cost efficiency



The flexible hydraulic tool offers precise handling without friction and power transmission loss in minimally invasive surgery.

The benefits of endoscopy as a minimally invasive procedure over operations that involve large incisions are well documented. However, surgeons who use endoscopic instruments reach a point where they cannot go on: simple jobs are physically stressful for the surgeon. Mechanical power transmission through wire ropes or driving rods in flexible and bendable instruments is particularly low and generates high friction levels. This might lead to injuries at the site where the incision is made and in deeper tissue layers. PAMB is therefore aiming to develop more powerful tools and special precision systems with ergonomic interfaces and hydraulic systems that do not require the operating surgeon to use a lot of strength. Surgical instruments that hydraulically transmit power to blades, gripper jaws or bends operate more smoothly.

“In contrast to mechanical instruments, which often require complicated installation and cleaning, PAMB’s innovative instruments are cheaper and give rise to new possibilities,” says Stallkamp, highlighting the benefits of such instruments. Cost efficiency is an important aspect that PAMB is also working on in a project called “Man-machine teams in the operating room”. Manually performed operations such as laparoscopic surgery are associated with the problem that simple jobs are very physically stressful for surgeons, and long set-up times as well as expensive equipment increase the cost of such interventions. For this reason, computer scientists in the Fraunhofer Project Group for Automation in Medicine and Biotechnology are carrying out research into cooperative human-machine teams in the operating room to try and find a way to combine the flexibility benefits of a manual approach and the precision of automated, computer-assisted operations. The modular system under development will enable endoscopes and associated instruments to be used manually as well as enable control and precise handling by innovative

automation systems.

Another one of PAMB's major achievements is the non-linear drilling robot, a miniature robot for removing tumours from the inner ear. The robot is capable of adjusting its path while drilling a tunnel of 5 mm in diameter through the petrous bone to steer around sensitive tissue such as blood vessels or nerves. The hydraulic tubes enable the robot to drill around corners. It can be precisely controlled. An advanced prototype of the robot presented at last year's MEDICA attracted a great deal of interest.

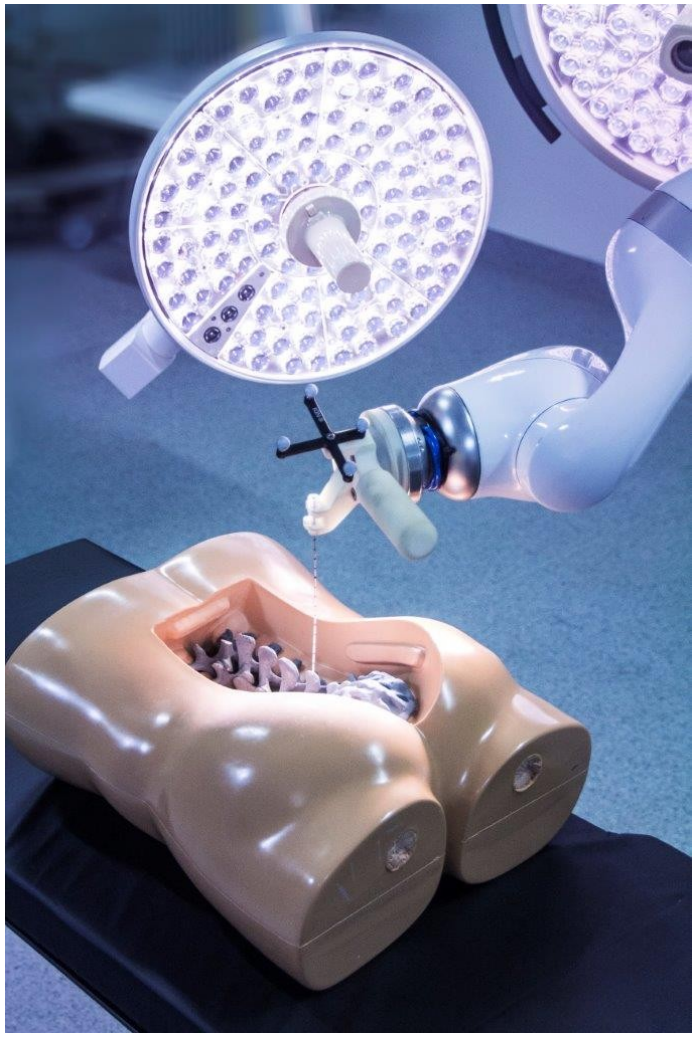
Diagnosis and therapy of oligometastatic patients as a "one-stop shop" in a single session

PAMB is trying to turn something that tumour patients, especially those with four to six metastases (oligometastatic), dream of into reality: the possibility of undergoing complete diagnosis and treatment within a few hours. The focus of this ambitious approach is the integration of many interventional radiology clinical procedures into one system. Imaging data (X-ray and fluorescence images, and in the future possibly also CT and MRI images) will then be analysed in detail by experts from the fields of biotechnology, physics and computer sciences and merged by clinical specialists into a single dataset. A particularly innovative feature is the generation of three-dimensional image datasets of patients with one X-ray device coupled to a robot (ArtisZeego®, Siemens Healthcare). The aim is to produce real-time image data and perform subsequent radiological treatment in a continuous procedure involving another instrument-guiding robot. Both automated systems are located on a mobile platform that combines diagnostic and therapeutic systems.

The project M^2OLIE (Mannheim Molecular Intervention Environment), which is funded by the BMBF, involves PAMB, Mannheim University of Applied Sciences, the Universities of Heidelberg and Mannheim, the DKFZ and industry partners. The aim of the project is to treat tumours not in the organ or tissue, but on the cellular or even molecular level. A biopsy needle will be positioned automatically at the site identified by the imaging systems, if possible in a compressed period of five to ten minutes.

Biopsies, i.e. the removal of suspicious tissue, provide important disease information derived from tissue with a certain number of intact tumour cells. Therefore, a large piece of tissue needs to be removed and gently separated into individual cells for use in subsequent analyses. PAMB is trying to bypass this loop by developing a novel system for the endoscopic removal of a tissue sample and coupled inline analysis. The results can then be integrated into datasets and used as the basis for subsequent therapy sessions (radiotherapy, excision, thermoablation).

The interdisciplinary researchers, physicians and industry partners are still in the development phase. However, if they manage to successfully develop an efficient and valid method, it will be a milestone in the history of tumour diagnosis and therapy. The overarching goal of all PAMB developments is to enable efficient and rapid treatment, facilitate surgeons' work through automated processes and thus ensure increased safety.



Intervention assistant carrying out initial biopsies involving a spinal phantom. The integration of an automated instrument changer ensures a faster workflow.
© Project Group for Automation in Medicine and Biotechnology (PAMB)

Article

14-Mar-2016
Simone Giesler-Güllich

Further information

- Fraunhofer Project Group for Automation in Medicine and Biotechnology PAMB, Mannheim
- CUBEX41

The article is part of the following dossiers

Medical technology – serving healthcare

New machines for the life sciences

automation | diagnostics | medical technology | technology transfer | imaging methods | multidisciplinarity | core facilities