

Health and Medicine

Improving health care, increasing the chances of healing, supporting diagnoses – these are the goals that the Fraunhofer-Gesellschaft wants to achieve with results in medical, environmental and nutrition research. Intelligent, assistive systems that support preventive health care, diagnostics, therapy and nursing are intended to help in this. We are focusing in particular on tools for decision support in therapy planning and for strengthening resilience, but also for political decision-making in order to contain the Corona pandemic.

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Increasing Chances of Survival through Mathematics

It is a Fraunhofer ITWM success story that has improved the lives of many people: thanks to the planning techniques for radiotherapy developed here, the survival chances of people suffering from cancer have increased significantly. These planning techniques were implemented by Varian Medical Systems, the world's largest manufacturer of radiotherapy equipment, which has been part of Siemens Healthineers since 2021. The collaboration is ongoing.



Radiation therapy is about a trade-off between treatment of the tumor and the risk of side effects. Market leader Varian Medical Solutions relies on software solutions from Fraunhofer ITWM.

The decision support components are used in planning tasks in many different applications in industry. The goal when used in radiotherapy is to reach a sufficiently high dose to the tumor while minimizing the negative impact on surrounding healthy tissue. In this way, severe side effects are avoided in treatments every day in many hospitals around the world, while at the same time increasing the likelihood of successful treatment.

Time as a Decisive Factor in Treatment

Improving planning efficiency as well as higher quality of treatment were the aspirations for the multi-criteria radiotherapy planning tool developed in the Optimization division from the beginning of the collaboration. "For many patients, the time factor is crucial to the success of treatment. We have given treating phy-

sicians the opportunity to create very good and personalized therapy plans without having to use a time-consuming trial-and-error procedure," says Dr. Philipp Süß, deputy department head "Optimization – Technical Processes."

Collaboration Continues

Palo Alto-based Varian Medical Solutions is the market leader for radiation oncology equipment. In 2016, the cooperation with Fraunhofer ITWM started; the joint product has been on the market since 2017 and has since been offered in more than 150 countries. Now the collaboration has been extended for another five years. "We are all proud of what we have already achieved together with one of the most successful global players in medical technology and look forward to continuing our joint work to further improve radiotherapy," said Süß.

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Software-Optimized Production Processes at BioNTech

Since the Mainz-based company developed the first broadly approved vaccine against COVID-19, the name BioNTech has been widely known. The real concern of BioNTech SE is the development of individualized therapy for cancer patients. For both use cases – the production of the individualized cancer drugs as well as the Corona vaccine – researchers of the Fraunhofer ITWM have developed a software platform, with which the production process can be controlled more effectively.

The production of individualized drugs is complex from both a technical and organizational perspective and differs fundamentally from established processes in the pharmaceutical industry. Individualization raises a variety of novel issues and requires new approaches to production organization and planning. For example, all steps must be carried out individually for each patient. For many years, this was not the focus of established solutions for production planning.

Customized Solution

To develop a platform that plans and coordinates these processes is the task of the team around Dr. Heiner Ackermann, head of the department "Optimization – Operations Research". First, the previous knowledge of the scientists at BioNTech had to be combined with that of the ITWM researchers. "Finding a common language, a common understanding

of processes, was an essential part of our work," says Ackermann. Modeling, structuring, and analyzing data and processes followed. The end result was software that could be used to plan and organize the manufacturing processes of the individual drugs, and which provides a completion forecast for the respective patients.

Automated Processes for Increasing Production Figures

Several of BioNTech's oncology product candidates are already in advanced stages of development and will soon enter pivotal trials. Production for commercial distribution is already being prepared today. This also has an impact on the planning processes: They sometimes need to be adapted and expanded, particularly with regard to greater automation. Preparations for this are already underway. "With a few hundred patients, manual intervention in the process is still possible. This will no longer be possible with several 10000. Automated processes and additional decision support options may be required there," says Ackermann, describing the advantages of an automated planning process.

The researchers at Fraunhofer ITWM continuously adapt the software to the changing requirements of vaccine production.





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Whether cancer therapy or vaccine production – the Fraunhofer ITWM and BioNTech develop software to improve the planning, coordination, and documentation of complex production processes.

And Then Came Corona

With the onset of the Corona pandemic, BioNTech is also using its expertise on mRNA-based anticancer drugs to develop a vaccine. “I learned from a newspaper article that BioNTech was planning to develop a vaccine. Shortly thereafter, the company inquired about working with us on new software solutions. That’s when chaos briefly broke out for me, but of course we got to work,” Ackermann looks back.

The manufacturing process for the vaccine is much less complex than that for the individual cancer drugs. The critical issue here is production capacity for the hundreds of millions of

vaccine doses required. The solution is for BioNTech to work with contract manufacturers who specialize in certain process steps.

The Fraunhofer ITWM and BioNTech have established software that allows the company to plan, coordinate, and document the production network and the individual process steps. “Now we are working on adapting the platform to the ever-changing requirements. As the production process evolves, we are also developing the platform. In some cases requirements change on a weekly basis, but this is a challenge that we’re coping very well with,” says Ackermann, describing the ongoing collaboration.

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Corona Pandemic: Fraunhofer ITWM Advises State Government of Rhineland-Palatinate



During the Corona pandemic, the weekly forecasts for the expected infection numbers by Fraunhofer ITWM are important indicators for the state government of Rhineland-Palatinate to make political decisions. Our researchers have contributed to the fact that the state has weathered the pandemic better than other German states.

“The forecast for the coming days” – a phrase you’re actually more familiar with from weather reports, but not in connection with hospital loads, intensive care bed occupancies and mortality rates. In the Corona pandemic, the forecast of the number of infections is a crucial factor in deciding whether to tighten or loosen protective measures.

Provide decision makers with solid foundations

In April 2020, Fraunhofer ITWM began making forecasts of pandemic developments. Initially, in order to better prepare hospitals, municipalities, and public health departments for what was to come. “It was clear to us: we can calculate what’s coming. Then we asked the district councils and mayors in Rhineland-Pa-

latinate whether they needed help. For the political players, our calculations were authoritative decision-making criteria.”

Behind the forecasts is a dedicated team that brings together diverse expertise and experience across departments to jointly contribute to pandemic response. The accuracy of the predictions is remarkable. The Rhineland-Palatinate state government is also aware of this fact, so that a weekly meeting has been arranged with representatives of the Ministry of Science and Health and the State Investigation Office since August 2021. The results received attention by several ministries and by Minister President Malu Dreyer. The cooperation is having an effect: Rhineland-Palatinate is coming through the pandemic relatively unscathed.

Contact

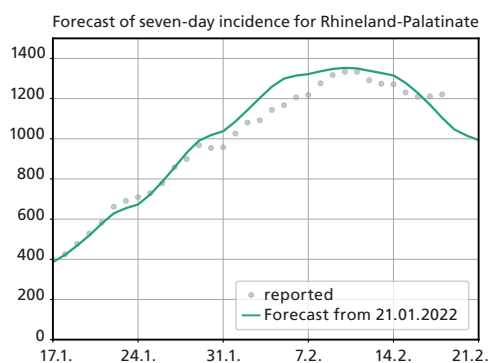
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Calculating the Future From the Past

“We have developed a simulation and forecasting program to look into the future based on reported values from the past,” says Dr. Jan Mohring from the “Transport Processes” department. What is modeled is how the infection figures develop. Parameters are contact, testing and vaccination rates. The dynamic events are reconstructed on the basis of the numbers recorded over the last few weeks. For this purpose, the contact and detection rates are adjusted so that the model reproduces the reported new infections and deaths for the past. The parameters found are then used to extrapolate the spread dynamics into the future. From this, forecasts can finally be made for indices such as mortality rates or intensive care bed occupancy rates.

During the pandemic, the system could be increasingly supplemented and adapted. The accuracy of the hits impressed everyone involved: “We predicted the peak incidence of the fourth wave in February 2022 for Rhineland-Palatinate to the day and the incidence with a deviation of about 20 cases – and that three weeks in advance,” says Mohring. This also makes it clear that testing is an important part of the pandemic response. In Mohring’s



The maximum of the Omikron-BA.1 wave was predicted three weeks earlier with a deviation of less than two percent.

view, even more crucial than contact restrictions, which is why Fraunhofer ITWM was an early advocate of representative testing in

schools as a containment measure. The state was also one of the first to introduce 2G-Plus on the advice of Fraunhofer ITWM.

Mirroring Human Behavior

With relaxations in the summer and the scaling back of regular testing, it became more difficult to provide concrete forecasts. However, since a changing detection rate is explicitly taken into account, forecasts remain at least possible with trade-offs in accuracy. Therefore, the Fraunhofer ITWM continues to work on its modeling software and is starting a new project with the Catastrophe Research Center from Berlin and the German Research Center for Artificial Intelligence (DFKI), in order to be able in the future to incorporate feedback that takes greater account of people’s behavior more closely. “Central to this for us is the question is how knowledge of a threat situation influences people’s influences people’s behavior,” says Mohring.

When Will the Pandemic Be Over?

The question about the end of the pandemic has often been asked to the researchers of Fraunhofer ITWM. There is a consensus: We will not get rid of Corona any time soon. Depending on the prevailing variant of the virus, the summer months will be more summer months will be more relaxed than the cold seasons. Küfer and Mohring agree, however agree: “The fall wave will roll.” Measures will depend on the particular variant of the virus. The consulting services of the Fraunhofer ITWM for the state of Rhineland-Palatinate will continue.

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