Fraunhofer Institute for Medical Image Computing MEVIS

Embedded in a world wide network of clinical and academic partners, **Fraunhofer MEVIS** develops real-world software solutions for image-supported early detection, diagnosis, and therapy. Strong focus is placed on cancer as well as diseases of the circulatory system, brain, breast, liver, and lung. The goal is to detect diseases earlier and more reliably, tailor treatments to each individual, and make therapeutic success more measurable. In addition, the institute develops software systems for industrial partners to undertake image-based studies to determine the effectiveness of medicine and contrast agents. To reach its goals, Fraunhofer MEVIS works closely with medical technology and pharmaceutical companies, providing solutions for the entire chain of development from applied research to certified medical products.

The **Fraunhofer-Gesellschaft** is the leading organization for applied research in Europe. Its research activities are conducted by 67 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 23,000, who work with an annual research budget totaling 2 billion euros. Of this sum, more than 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

Demo Stations at the Open House on June 4, 2014

The Open House will display solutions being brought to the market by Fraunhofer MEVIS with other industry partners, but also research projects and methods that are currently clinically evaluated.

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DEMO A

A safe therapy choice for stroke patients: Fraunhofer MEVIS researchers support clinicians with a training tool

In an acute stroke in the brain, a blood clot can successfully be dissolved using thrombolytic drugs. If the stroke occurs at night during sleep, however, administering the drug can be problematic. It can only be used safely and in accordance with current treatment guidelines during the first four and a half hours after a seizure, after which the risk of intracranial bleeding increases. Therefore, it is important to determine the time of stroke occurrence as accurately as possible. Researchers in the EU-funded WAKE-UP project are searching for a solution to the temporal bounds of the occurrence of stroke with the help of special MR imaging sequences called DWI and FLAIR.

DWI images show the Brownian motion of water molecules in the brain (diffusion imaging), whereas FLAIR images show anatomical structures inside the brain. If parts of the brain are not supplied with enough blood after a stroke, therefore reducing oxygen and glucose levels, pathological water and electrolyte imbalances occur in the nerve cells . Water molecule movement is clearly visible in the DWI image, and pathological changes can be seen in the medical images after only a few minutes. The lack of blood supply to the brain results in cell death and tissue destruction. These changes can be seen a few hours later in the FLAIR images. Researchers believe that if a diffusion disorder is seen on a DWI image but not on the FLAIR image, the stroke occurred less than three to four hours before, in which case thrombolytic therapy could still help the patient. However, if changes are visible in both images, the stroke most likely occurred more than four hours before. In this case, medication would constitute an unacceptable risk of bleeding for the patient.

As part of the WAKE-UP project, MEVIS is developing a training tool to support physicians in confidently interpreting and evaluating DWI and FLAIR images. In the future, the experts will also be provided with automated tools for analyzing stroke images.

The demo station presents both the training and the analysis tool as well as research prototypes for neurosurgical planning, neurological follow-up, and Alzheimer's diagnosis.

See also:
WAKE-UP project page

DEMO B

Innovative pathology methods to classify tumors with proven accuracy

To safely determine whether a lesion is malignant, the precise examination of a tissue sample by a pathologist is usually necessary. Tissue samples are usually observed and evaluated using a microscope. This is not the case with recent developments in digital pathology. Here, the tissue sections are first digitized. The samples can be better measured and analyzed and more easily archived and transfered between hospitals for a second pathologist's opinion. Researchers at Fraunhofer MEVIS are developing appropriate software for these processes in digital pathology.

The digital tissue section images have a very high resolution. This provides detailed views, but also generates large amounts of data. With conventional methods, data processing takes so long that they are used by pathologists for research purposes but not in their daily routine. MEVIS researchers have developed algorithms and procedures that reduce the processing time for complete tissue sections from hours to minutes. In addition, the method can automatically measure important tissue properties, considerably increasing the accuracy and reliability of a diagnosis made by the pathologist.

Pathologists can search for relevant image regions and at each point of the scale and zoom in or out freely. Tissue displacement and deformation caused by the sectioning process can be offset by image registration. Furthermore, the system can visualize and evaluate immunostaining in a common image to give, for example, information about inflammatory processes or the content of fat vacuoles. Moreover, it can automatically classify tumor tissue into different categories and identify different tissue types. This produces highly informative three-dimensional tissue images.

The demo station shows the workflow from tissue section to digitized slides. Visitors can independently select an area from the digitized tissue image and register two neighboring tissue slides. The result can be examined interactively by overlaying the registered images and the information contained within.

See also:
Fraunhofer MEVIS solution: Histology in New Dimensions
Fraunhofer MEVIS solution: Registration-Aided Applications
Link to Image: Three-dimensional reconstruction of a lung tumor from 180 different series of histological sectional images.

DEMO C

Fusing information from different medical images for better breast diagnosis and therapy planning

For breast cancer diagnosis and treatment, it is important to identify tumors as early as possible and classify them with high specificity. Tumors can be visualized using many different imaging techniques (modalities) to show various properties. To clarify the status of the tissue in question, different imaging methods are used, such as 2D / 3D breast ultrasound, mammography, MRI, and tomosynthesis. This lets clinicians better detect microcalcification, an indicator for certain types of tumors. With the help of ultrasound, however, clinicians can more easily distinguish between benign cysts and malignant tumors.

To assemble this array of information into an overview is a large task: the images of the breast are deformed differently for each modality. In mammography, the breasts are clamped between two plates, and in ultrasound, the breasts are pressed against the ribcage. To support these clinical workflows and merge the information of the images quickly and automatically, a position correlation is performed using so-called registration procedures.

All image positions are mapped onto a generalized breast model, the basis for correlating information between the different recordings. This allows fast, automatic orientation in large amounts of data and is an important step towards automatic detection, diagnosis, and treatment planning for breast cancer.

Visitors can test several workstations and discover what it means to find suspicious tissue in medical images of the breast with or without spatial correlation between modalities or over time.

See also:
Fraunhofer MEVIS solution: Position Correlation between Multimodal Breast Images
Link to Image: Breast cancer characterized with different imaging techniques that are put together into a common coordinate system.

DEMO D

Use Your Hands to Read: Fraunhofer MEVIS researchers are developing gesture-based approaches for breast diagnosis and therapy planning

To diagnose and treat breast cancer, more and more imaging methods are being used, including mammography, magnetic resonance imaging, and ultrasound. To support breast examinations and screening more efficiently, Fraunhofer MEVIS researchers have combined mobile devices and computer workstations to develop an innovative approach to improve clinical workflows and aid clinicians in dealing with a wide variety of image information. The goal is for clinicians to be able to evaluate image data and large amounts of information quickly and with ease, personalization, and comfort.

Using the slogan "Use Your Hands to Read", gestures on an iPad are used to navigate through different images that are displayed on workstation monitors instead of a small mobile touchscreen. Images of the patient taken at different time points with different imaging methods (modalities) can be comfortably observed and reviewed together in one workflow.

Combining interaction on the mobile device with the display of the real images on the monitor of the workstation is novel and opens up numerous possibilities that would be otherwise impossible. An application to patent the approach has been filed in Germany and the United States.

Visitors can test an iPad-controlled MR diagnostics work environment or a gesture-based screening workstation. Custom tools for measurement, segmentation, and navigation will be shown. The classical combination of mouse and keyboard can also be tested for comparison.

See also:
Interview: Use Your Hands to Read
Fraunhofer solution: Computer Assistance for Breast Imaging: From Screening to Therapy

DEMO E

Researchers at Fraunhofer MEVIS are developing an application for robot-assisted prostate biopsy in cooperation with Soteria Medical from the Netherlands

An elevated PSA level in the blood may indicate prostate cancer. When this value in a patient increases, clinicians attempt to determine if the prostate is afflicted with cancer by taking a tissue sample. The removal of this sample is often psychologically and physically stressful for patients. A clinician probes the prostate and typically takes tissue samples at twelve locations. If no evidence of cancer is found in the tissue, but the PSA value is still increasing, the biopsy samples simply might not have been taken from affected tissue. In this case, the patient must undergo another biopsy. Patients who have already undergone this procedure several times receive MR-guided biopsies.

To position the biopsy needle correctly in the tissue, physicians manually insert a needle guide into the rectum of the patient and then scan it using MRI. They can then see both suspicious tissue as well as the position of the needle guide on the MR image. If the position is not correct, the patient is removed from the scanner and the needle guide is repositioned. Until the desired location is reached and the tissue sample can be removed, the procedure must be repeated several times - a burden for the patient. Moreover, the process is costly, occupying the MR scanner for an extended time.

An innovative robot system increases the accuracy and speed of positioning the needle guide compared to manual systems. MEVIS researchers have brought MR image data and robot position information together in a certifiable application. While the patient is in the MR scanner, the robot controller can precisely guide and position the needle. The motors that steer the robot in the scanner can not contain any metal parts so as to not distort the MR measurement. These robots and the overall system were developed by Soteria Medical.

Visitors to the demo station can try out the workflow using the software.

DEMO F

Biophysical simulation of tumor therapy with high-intensity focused ultrasound, a promising and gentler alternative to surgery

Ultrasound can do more than take images of the inside of the body: it can also destroy tumors. Intense, concentrated ultrasound beams are directed into the body of the patient so that the diseased tissue is heated to over 60 degrees Celsius. This non-invasive form of therapy can be a gentler and often more cost-effective alternative to surgical operations. However, focused ultrasound has so far only been approved for a small number of diseases, such as prostate cancer, bone metastases, and benign uterine tumors (fibroids). Treating organs such as the liver with ultrasound presents two difficulties: the respiratory motion of the patient must be taken into account and ribs are often in the way of the sonication path.

Fraunhofer MEVIS has developed a software system to simulate treatment and provide accurate planning. To ensure that concentrated ultrasound beams hit the liver tumor, organs that move during breathing must be tracked. Thus, the simulation accounts for the respiration of the patient and the resultant movements of the liver. In addition, it considers whether the tumor is blocked by ribs. This helps the software predict whether the treatment will be successful and create an optimized treatment plan. This improves the quality of the treatment plan.

The demo station for high-intensity focused ultrasound treatment presents a simulation of patient-specific therapy. The demo exhibits a software prototype that supports the entire process, from processing image data to intervention planning to implementation. Also on display is an ultrasound transducer used by Fraunhofer MEVIS to evaluate research results.

See also:
Press release: Liver therapy with ultrasound - Fraunhofer MEVIS coordinates EU-project for further development of an innovative, conservative therapy
Fraunhofer MEVIS Solution: High-intensity Focused Ultrasound: Software Assistance for Tumor Therapy
Link to image: Numerical simulation of a liver tumor therapy with high-intensity focused ultrasound.

DEMO G

Needle-based tumor interventions with radiofrequency ablation: the SAFIR software prototype offers radiologists multiple forms of support to completely destroy tumors

Radiofrequency ablation (RFA) has become an established treatment option in clinics to eliminate small tumors in the liver. In this minimally invasive form of therapy, a clinician inserts a needle-like applicator into a tumor. Electrodes attached to the applicator transmit high-frequency energy to the diseased tissue, heating it up to 100 degrees Celsius, thus destroying it. However, the treatment is successful only if the tumor is completely destroyed, otherwise cancer cells could remain the body. This is where conventional RFA is weak: clinical studies show a high rate of incompletely ablated liver tumors.

To ensure that a tumor is completely destroyed, Fraunhofer MEVIS has developed the SAFIR software package (Software Assistant for Interventional Radiology) to provide attending radiologists with a wide range of support. It visualizes tumors and risk structures, such as blood vessels, in three dimensions. As a result, clinicians can view all important anatomical structures inside the patient in three dimensions during the planning stage of the procedure. In addition, the software can simulate the amount of tumor destruction caused by heat in advance. This can be used to check whether the entire tumor has been destroyed or untreated areas remain. In addition, the system provides auditory feedback that facilitates the placement of needles during the procedure. Similar to a parking aid, the radiologist can guide the needle into the patient using auditory cues. Finally, the software supports radiologists when evaluating the success of the therapy. The software visually highlights potentially untreated tumor areas. The program compensates for liver deformation induced by breathing and movement.

The demo station shows the basic functions of the therapy system. It showcases the software prototype, which shows the range of clinical operations from treatment planning to needle navigation to the evaluation of therapeutic success.

Using a physical model of a patient, visitors can navigate a needle with the help of the optical tracking system with audio feedback.

See also:
Fraunhofer MEVIS solution: Software Assistance for Thermal Tumor Ablation
Link to image: Two radio frequency applicators inserted in the tumor

DEMO H

MEVIS researchers in the SPARTA project are working in close cooperation with clinicians and industrial partners to improve radiation therapy

Radiation therapy is one of the most important cancer treatment methods. Tumors are exposed to a high dose of targeted radiation. In intensity-modulated radiation therapy, a lesion undergoes individually calculated radiation doses from many directions. Clinicians use this method especially in cases for which tumors cannot be fully surgically removed. Because the beams of radiation are superimposed onto the tumor, they deliver the maximum dosage at that point. Ideally, the surrounding healthy tissue is only slightly affected. However, during the course of treatment, the size of the tumor may change, or the patient may gain or lose weight. This changes the position of the tumor within the body, thus shifting the radiation target. In addition, certain tumors in the body move when the patient breathes. This creates difficulties for the clinician, who must control the focus of the radiation to follow the tumor.

In the SPARTA research project (Software Platform for Adaptive Multimodal Radiotherapy and Particle Therapy with Autarkic Extendibility) Fraunhofer MEVIS researchers, along with nine other institutions, are developing adaptive and flexibly extendable software systems to support clinicians in planning and conducting radiation therapy. The aim is to inform the clinician about the therapy at hand, which is usually composed of several radiation sessions, and whether the therapy is proceeding according to plan and whether the treatment goal can be achieved. In addition, the systems are intended to indicate which quick customization processes are possible for each patient and what benefits they would provide. Finally, the treatment steps should be adapted to allow for the daily condition of each patient.

To achieve this, MEVIS is developing new methods, tools and processes for radiation therapists. These should allow the physician to be more aware of the radiation risk and the success of the treatment and, in the future, be more promptly informed about potential problems such as over- or underradiation.

The SPARTA demo station gives visitors a look at the preliminary results of the software. This includes concepts for user management and application design, improvements to work processes as well as new visualizations for multimodal image data.

See also:
Press release: Intelligent Software for Patient-Friendly Radiation Therapy
Fraunhofer MEVIS solution: Efficient Diagnosis Setup for Multimodal Radiation Therapy Planning
SPARTA project page

DEMO I

A Cloud and Browser-Based Applications Accelerate and Facilitate Clinical Studies

For their preclinical and clinical research, the pharmaceutical industry uses many medical imaging methods. Those such as magnetic resonance tomography help assess the effectiveness of new contrast agents and medicines and investigate the compatibility and safety of active substances.

These studies are often conducted at more than one medical center or clinic on a national or international basis. This places high demands for data management and the quality assurance of medical data. To analyze radiological images, for instance, special software is needed. Demands are also placed on hardware such as processors or special graphic cards. To ensure quality and meet standards, medical data for analysis must be centrally located and sent between individual study partners and the central collection center. However, individual study partners usually employ different hardware and software.

Fraunhofer MEVIS has developed a cloud- and browser-based software system which facilitates preparing, conducting, and evaluating clinical studies. Applications can be distributed to run in a browser, centrally administered and updated to synchronize different application versions. The medical researchers do not need powerful, specialized computers; these flexible applications can be run on any computer as well as on mobile devices. Anonymization and encryption tools provide for a secure procedure.

The "Web-Based Vessel Analysis" demonstration shows these new applications. The application helps measure, vessel constrictions (stenoses), which often occur in atherosclerosis. The software has already been used in an 'offline version' for a retrospective, image-based clinical trial that compared the contrast-enhanced MR images with CT angiography. This web technology could be easily applied to other applications such as measuring tumor size.

Visitors to the Open House can measure stenoses using CT and MR images using the browser-based tool and experiment with the basic version of this software.

See also:
Try the tool with your browser
Short tutorial movie