Computable Human Phantoms

三维人体组织医学电磁仿真软件平台

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三维人体组织电磁仿真软件平台 Sim4Life

Sim4Life Platform 三维人体组织电磁仿真软件平台 Sim4Life 概述

三维人体组织电磁仿真软件平台 Sim4Life 是由瑞士 IT'IS 基金会研发的，已获得瑞士 CTI 医疗科技奖，Sim4Life 平台结合可计算人类模型、最強大的物理解算器和最先进的组织模型，能直接分析人体真实世界和复杂技术设备，以及验证人体和解剖学环境之中的变化。Sim4Life 采用高性能计算和最直观 GUI 架构，能实现精确的多物理模擬，和无尽的定制加快研发活动，协助医疗及科研团队优化医疗器械和治疗方法，且同時符合最安全性和有效性的要求。

三维人体组织电磁仿真软件平台 Sim4Life 运作流程可分成 MRI/CT 3D 影像重建、解剖及产品模型导入(CAD)、多样化解算器、组织和物理模型、直观的分析报告及硬体验证等阶段，能够在取得多张影像资料之后，快速进行完整 3D 三维影像重建，再利用内建产品模型，产生接近真实狀況的模擬资料。而且产品本身支持市面上常見的模型软件，包含各种公开的人体解剖模型，绝对能够符合不同医疗环境的使用需求。

三维人体组织电磁仿真软件平台 Sim4Life 内建为计算复杂问题所设计的运算核心，包括 EM、热学、声波和流体求解，医疗研究单位只要安装在高效能电脑上，即可在最短時间內获得运算結果。此外，三维人体组织电磁仿真软件平台 Sim4Life 本身便有灌注模型，组织损伤模型和神经元模型，均是現今手术过程中使用頻率最高的元件，特别是软件本身可透过简单易于操作的图形化三维介面，协助操作者完成定义问题、离散，模擬和分析等步骤，能让模擬結果都更接近真实結果。

三维人体组织电磁仿真软件平台 Sim4Life 可精准掌握病情狀況，实现客制化医疗诉求，能够根据个体的差异，採取术前科学規划、术中精确定位、术后准确评估。Sim4Life 平台采用互动式动态建模方式，简单易用的下拉式建模工具列，不仅便于输入医疗设备产生的各种影像档，而只需利用滑鼠即可做视角缩放变换，轻松完成精确全人体三维模

型，顺利完成最适宜的治疗方案規划。Sim4Life 平台具备易于编写的特性，加上拥有线上強大资料库，用戶很容易产生适合自身医疗环境的工具库，也能即時調整平台的操作环境。所以软件推出至今，已許多客戶以此平台再创建了许多延伸应用，如 MRI 线圈设计、造影解析度改量、人体模型开发等等，堪称是打造客制化医疗的最佳工具。

以医学上常見的超音波刀进行肝臟肿瘤切除为例，过去在医师动刀之前多只有平面影像图可參考，只能約略掌握肿瘤位置与大小，因此手术成功率多半取决于医师的经验多寡，很容易因一時疏忽引发后续医疗纠纷。通过 Sim4Life 平台的模擬软件协助，医师能在手术之前即了解肿瘤位置与体积大小，所以就算经验较嫩的年轻医师，亦能順利完成肝臟肿瘤切除的手术作业。尤其是护理人员也因能預知伤口大小，能在术后照顾准备上更为充分，让病患享有最完善的照顾服务。再如电烧刀手术是另一种适合 Sim4Life 平台协助的医疗手术，该手术是针对心血管病变进行的治疗方式，但电烧刀电流密度高低与血管壁上剪应力分布息息相关。一旦电烧刀上的电流过大，便可能造成伤口出血过多，所以若能透过术前的模擬软件协助，则有助于提高手术的成功率。

Sim4Life 平台使得个性化医疗将不再是遙不可及的梦想，亦能降低医疗机械研究的成本，並符合各国法規的要求。特別是當医疗团队能够收集到更多资訊，为病人制訂專屬客制化医疗之后，不仅能創造出更好医疗效果，也能准确后续預測治疗結果，減少病患术后感染或藥物过敏的医疗纠纷，进而让寶貴医疗资源获得最佳利用。當客制化医疗能够逐步被实踐之后，立法机关也能制定一套更完善的治疗准則，对提升医疗照护品质与水准。在全球医疗观念不断提升之下，建构一套完善的健康管理平台，已成为現代医疗医学的新趋势。

一般來说，健康管理平台上收集到的资料有兩大用途，首先是作为医生治疗前的评估參考，如用药种类或是手术形式，其次則是将病历资料转换为更容易阅读的可视化图像。医院或研究单位若能够将前述两类资料，输入到多重物理模擬软件 Sim4Life 時，則有助于新医疗技术开发，进而为特定疾病研发出更有效的药物或治疗工具。

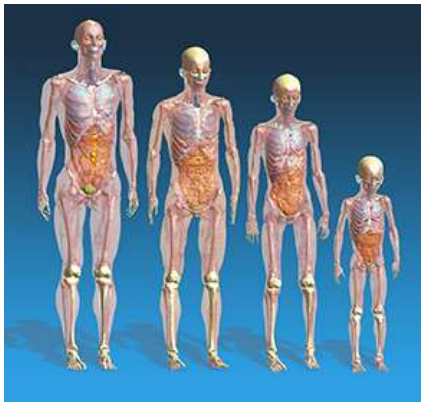
In silico

The digital revolution is extending the frontiers of medicine and medical technology. Computer modeling and simulation (CM&S), or *in silico* technologies, merge computational tools with biology to intuitively, precisely, and reproducibly perform complex analyses of life sciences applications. With this emerging paradigm, experimental manipulations that are infeasible or impossible to conduct in real-life experiments can be created while maintaining experimental control: the perfect complement to in vivo and in vitro studies. ZMT provides *in silico* solutions to the medical device industry. Our comprehensive simulation platform, *Sim4Life*, provides a powerful 3D validated biological and anatomical modeling environment for optimizing the effectiveness and performance of medical devices, improving patient safety, and discovering potential new treatments. Built from the ground up, *Sim4Life* provides smooth and fully automated or customizable workflows for applications ranging from exploratory research and medical device development to regulatory documentation for clinical trials and device certification.

we trust

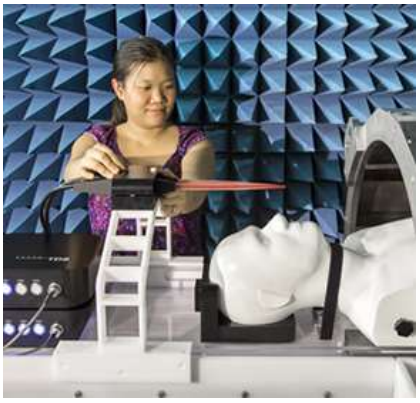
Our software tools are thoroughly and continually verified to ensure their reliability and performance requirements as they evolve. The same effort is on validation for our expanding portfolio of targeted life sciences models and applications.
ZMT also provides test systems for validation procedures that support complex requirements with software tools optimized for test and measurement systems.
At ZMT, we leverage the combined strength of our expertise, experience, cost-effective solutions, and commitment to long and fruitful client relationships to enhance your competitive advantage during the regulatory submission process.

Phantoms



Solvers & Tissue Models

Validation Hardware



Sim4Life

Sim4Life is the first computational life sciences platform integrating computable human phantoms with the most powerful physics solvers and the most advanced tissue models for directly analyzing biological real-world phenomena and complex technical devices in a 3D validated biological and anatomical environment.

All modeling capabilities from the segmentation of medical image data, anatomical and CAD model import, discretization and simulation to visualization and analysis are embedded and streamlined to offer the most versatile and efficient simulation environment possible.

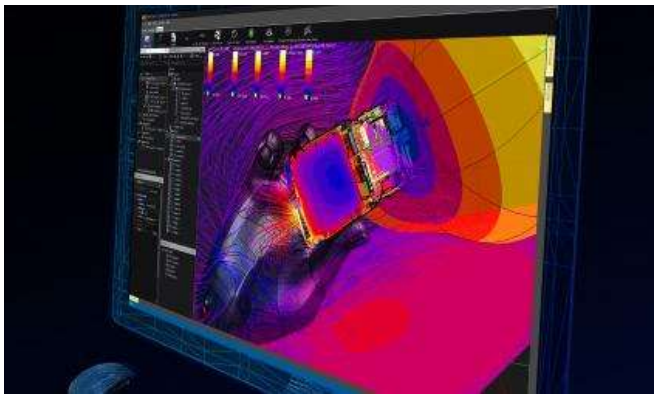
At the core of *Sim4Life* are the computable, high-fidelity 3D Virtual Population (ViP) human anatomical models. Carefully selected to fully represent global variations in human anatomy, the fully posable, morphable, and validated ViP models along with the IT'IS tissue properties database depict 15 different body types with 120 vital anatomical features and over 300 precisely identified tissues and organs. Cited and applied in hundreds of published studies and papers, the ViP models and the IT'IS material parameter database are continually and meticulously updated, refined, and expanded.

Sim4Life is a revolutionary simulation platform, combining computable human phantoms with the most powerful physics solvers and the most advanced tissue models, for directly analyzing biological real-world phenomena and complex technical devices in a validated biological and anatomical environment. The Sim4Life platform also offers leading performance with all the features expected from a multiphysics CAE/TCAD platform. Watch the Sim4Life demo video!

Computable Human Phantoms

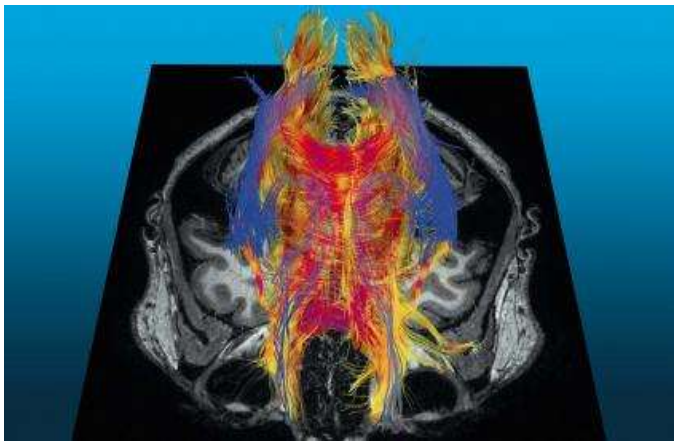
Sim4Life natively supports the Virtual Population ViP 3.0 models that include integrated posing and morphing tools. Other publicly available animal and human anatomical models are also supported. All tissues are linked to a continually updated physical properties database.

Physics Solvers



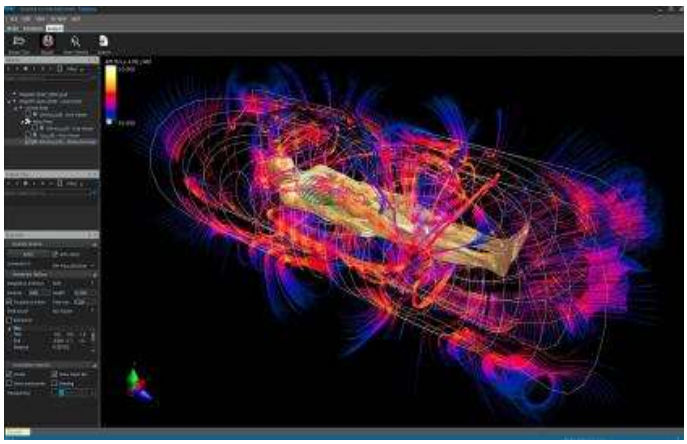
The powerful Sim4Life solvers are specifically developed for computationally complex problems; HPC accelerated for the latest computer clusters; and smoothly integrated in the most advanced coupling framework. The platform already includes EM, Thermal Acoustic, and Flow solvers.

Tissue Models



The integrated tissue models enable the modeling and analysis of physiological processes. Perfusion models, tissue damage models, and neuronal models are already included in the first release of Sim4Life.

Framework



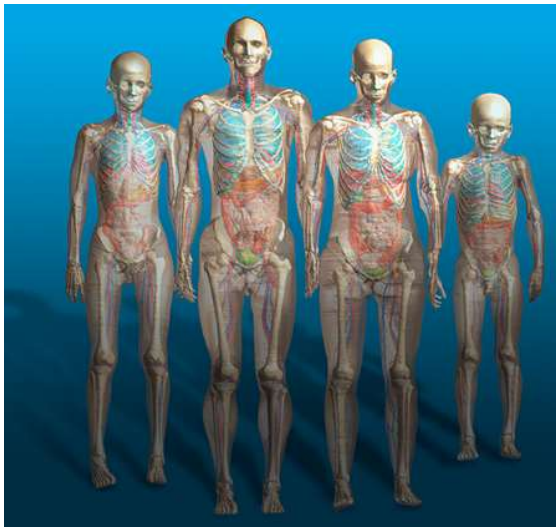
The Sim4Life Framework efficiently facilitates all steps in complex multiphysics modeling, from defining the problem, discretizing, simulating, and analyzing to visualizing the results, with clarity and flexibility.

Sim4Life Platform 三维人体组织电磁仿真软件平台 Sim4Life 组成

Computable Human Phantoms 可计算人类仿真软件	Physics Models 物理模型	Tissue Models 组织模型	Intuitive GUI and Workflow 直观的图形用户界面及集成平台	Licensed Modules 可授权模块
ViP 3.0 Virtual Population	P-EM-FDTD Electromagnetics Full Wave Solvers	T-NEURO Neuronal Tissue Models	iSEG Medical Image Segmentation Tool Set	MRI M-MUSAIK M-TxCOIL M-BCAGE M-SYSSIM M-GRAD M-IMSAFE
ViA 1.0 Animal Models	P-EM-QS Quasi-Static Electromagnetics Solvers	T-CEM43 Tissue Damage Models	MODELER Advanced Modeling Tool Set	
Third-Party Models	P-THERMAL Thermodynamics Solvers	T-FLOWRATES Flow Rate Computational Engine	MESHER Robust & Effective Meshing	MODELING M-REMESH M-POSER
	P-FLOW Fluid Dynamics Solvers		ANALYZER Versatile Postprocessor and Analyzing Tool Set	CALCULATORS M-DISPFIT M-PPCALC
	P-ACOUSTICS Acoustics Solvers		PYTHON Control via Python Scripting	PROCESSING M-MATCH M-TALATLAS M-MBSAR M-PHARRAY
	P-CRD Convection Reaction Diffusion Solvers (coming soon)			
	P-MECH Mechanical Solvers (coming soon)			IMPORT M-HUYGENS M-IMG M-VOX
	High Performance Computing Auto-Scheduler & Control ARES			

Computable Human Phantoms-ViP 3.0 可计算三维人体组织仿真软件-ViP 3.0

At the core of Sim4Life is a comprehensive set of computable human phan0[toms empowered by the most powerful physics solvers and the most advanced tissue models, providing a realistic biological and anatomical ;[environment for conducting fundamental mechanistic studies, testing the effectiveness and safety of medical devices and treatments, and supplementing clinical trials. Based on the Virtual Population ViP3.0 models of the IT'IS Foundation at ETHZ, the computable phantoms are characterized to predict real-world biological and physiological phenomena for any defined patient population. All tissues are linked to a continually updated physical properties database.



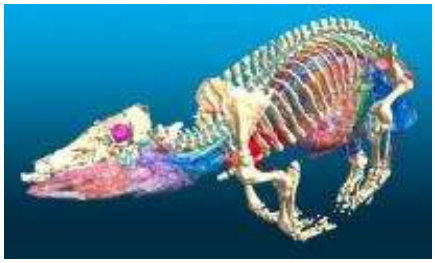
The powerful Sim4Life meshers allow high fidelity discretization of the complex computable human phantoms combined with any implant or external device.

A complementary interactive morpher extends the demographic coverage of the parameterized anatomical models, e.g., to explore underrepresented or pathological anatomies in clinical trials. A flexible poser is also included with the models.

Physicians and biologists rigorously validate the models and the associated database. Comprehensive documentation for all natively supported computable human phantoms is available.

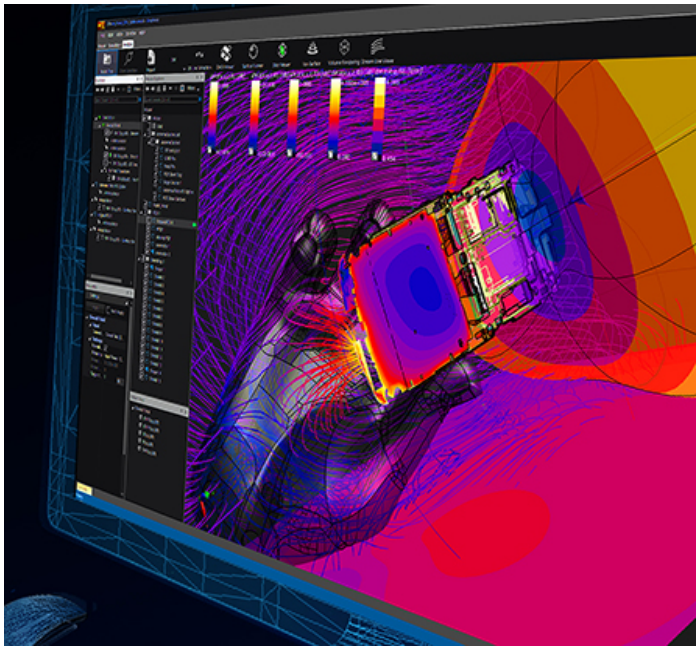
Key Features

- Native support for the latest generation of the Virtual Population ViP3.0
- Largest library of 3D high resolution CAD-based phantoms available on the market
- Grid-independent (not based on voxel data), CAD-based anatomical phantom data
- More than 15 full body anatomical human phantoms
- More than 10 anatomical head models (children, adult, male, female, European, Asian)
- Large high-resolution CAD animal models (or voxels via Brooks AF Base voxel data)
- More than 10 small animal models (rat, mouse, young, adult, male, female, pregnant, etc.)
- High resolution head model with integrated detailed deep brain structures and anisotropy information
- Integrated generation of high quality surface models from voxel and image data
- Posable anatomical models and support for the parameterization of additional models
- Interactive model morphing tool
- Generic birdcage CAD models
- Validated standard and measurement phantoms (e.g., SAM V4.5, Eli, CTIA/hands, DASY phantoms, etc.)



Physics Models 物理模型

P-EM-FDTD ： Electromagnetics Full Wave Solvers 电磁全波段解算程序



The Electromagnetics Full Wave Solvers (P-EM-FDTD) enable accelerated full-wave, large-scale EM modeling (> billion voxels) using Yee discretization on geometrically adaptive, inhomogeneous, rectilinear meshes with conformal sub-cell correction and thin layer models, offering support for dispersive materials. The solvers also include many unique features for EM safety assessments (see IMSAFE).

Optimal simulation speed is achieved with native GPU and MPI accelerations, which were developed by our team that first introduced EM accelerated solvers together with Acceleware in 2006.

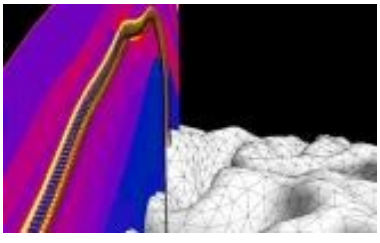
The unique bidirectional Huygens box approach overcomes the difficulties associated with models that extend across multiple scales and require strongly varying resolutions.
As the most frequently applied solvers in near-field dosimetry, they have been extensively validated and documented according to the IEEE/IEC 62704-1 standard as well as by comparisons with measured data (> 200 publications). Comprehensive documentation is available for Sim4Life.

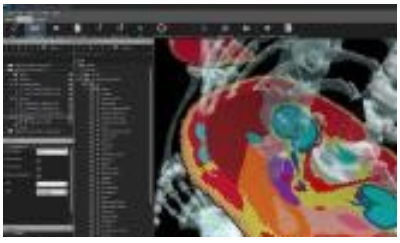
Application Areas

- MRI pTx RF Coil Design
- MRI Rx RF Coil Design
- MRI RF Coil Design with Gradient Interaction
- MRI Tx RF Coil Design w/ Gradient Interaction & Safety
- MRI Gradient Coil Design
- Active and Passive Implants MRI Safety
- RF Hyperthermia
- RF Tumor Ablation
- Biomedical Devices
- SAR Assessment

Key Features

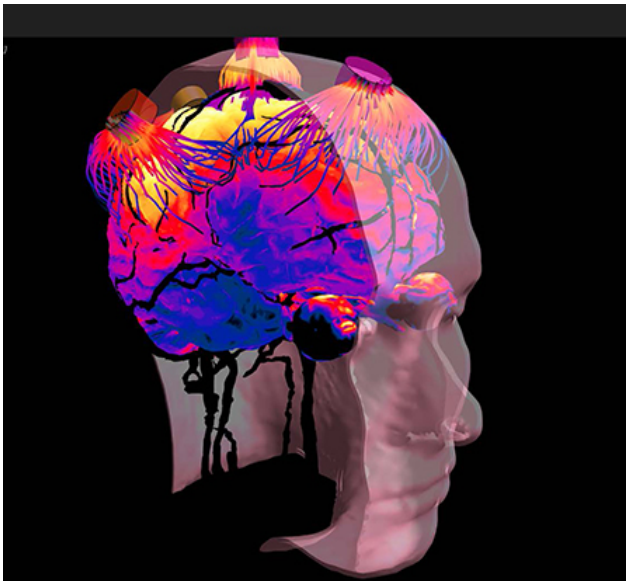
- Transient, Broadband, and Harmonic simulations (Time-Domain Solver)
- Results from time and frequency domains
- Automatic simulation termination
- ARMA engine for early time convergence detection
- Non-homogeneous intelligent gridder engine (geometry detection)
- Run-time monitoring
- Lossy dielectric and magnetic materials
- Frequency-dependent dielectric and magnetic materials (Debye, Lorentz, Drude, Drude-Lorentz)
- Metamaterials (double negative)
- Non-linear materials (Kerr-Effect, Raman-Scattering)
- Lossy real metals, thin metal sheets and coatings
- Temperature relevant parameters for T and EM-T solver
- Predefined materials database (metals, dielectrics, anatomical)
- User-defined signal source (pulse, step, saw, arbitrary, etc.)
- Discrete sources (1-D, single edge)
- Plane-wave and Huygens box sources (total-field /scattered-field)
- Remote and Iterative Huygens engines (incl. backscattering)
- Lumped elements (R, L, C, predefined serial/parallel)
- Parametric sources, lumped elements, sensors
- ABC, PEC, PMC, periodic boundaries
- Analytic boundaries (Mur, Higdon)
- UPML and CPML boundaries with adjustable absorption
- Execution through Command Line or GUI
- SIBC accelerated for Broadband and Harmonic simulations
- Fully automated multi-port SParameter extraction
- Results of S-Parameters extracted vs. frequency or in steady state





P-EM-QS：Quasi-Static EM Solvers 准静态电磁解算程序

The Quasi-Static Electromagnetic Solvers (P-EM-QS) enable the efficient modeling of static and quasi-static EM regimes by applying the finite element method on graded voxel meshes. The solvers address the most challenging low frequency problems at the cutting edge of medical and EM compliance applications, e.g., simulations of EEG, MRI gradient coil fields, transcranial magnetic or current stimulation, and deep brain and spinal cord stimulator implants.



Each solver is optimized for a different approximation of Maxwell's equations, offering improved speed, convergence, and accuracy for a wide range of scenarios.

Measured data and user-defined field or current distributions can be used as sources.

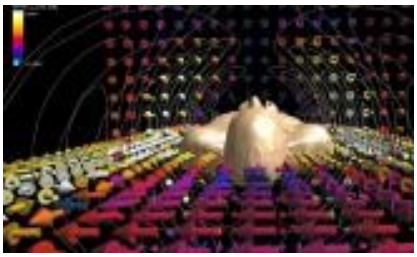
The P-EM-QS solvers have been validated and the uncertainties have been quantified using analytical and full-wave solutions and by comparison with measurement data. Comprehensive documentation is available for Sim4Life.

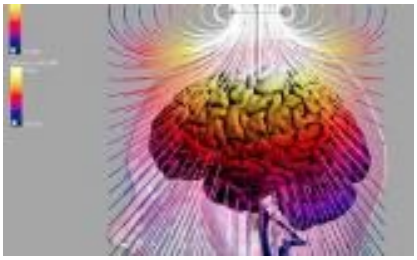
Application Areas

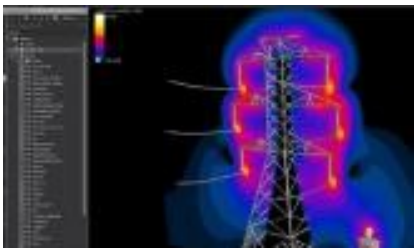
- MRI RF Coil Design w/ Gradient Interaction
- MRI Tx RF Coil Design w/ Gradient Interaction & Safety
- MRI Gradient Coil Design
- EEG / ECG
- Deep Brain & Spinal Cord Implants
- Transcranial Magnetic or Current Stimulation
- LF Hyperthermia (e.g., with nanoparticles)
- Magneto Hemo-Dynamics
- Sound Exposure (e.g., in MRI)
- Neuro-Prosthetics (retina, cochlea, vestibular, motor)
- EM Neuro-Stimulation
- Neuro-Motoric Incapacitation
- High LF EM Field Safety Assessment (e.g., MR Gradient Coils)
- Physiotherapy Heating
- Magnetic Navigation
- Defibrilator Analysis
- Pacemakers

Key Features

- Automatic simulation termination
- Electrostatic and Electro quasi-static
- Magnetostatic and Magneto quasi-static with constant permeability
- 3D static solver
- 3D LF solvers, E/H integrated into *Sim4Life*
- FEM based (rectilinear grids)
- Non-homogeneous intelligent gridder engine (geometry detection)
- Coupled with Thermal solvers
- Floating metals in ES and EQS
- Results of S-Parameters extracted vs. frequency or in steady state

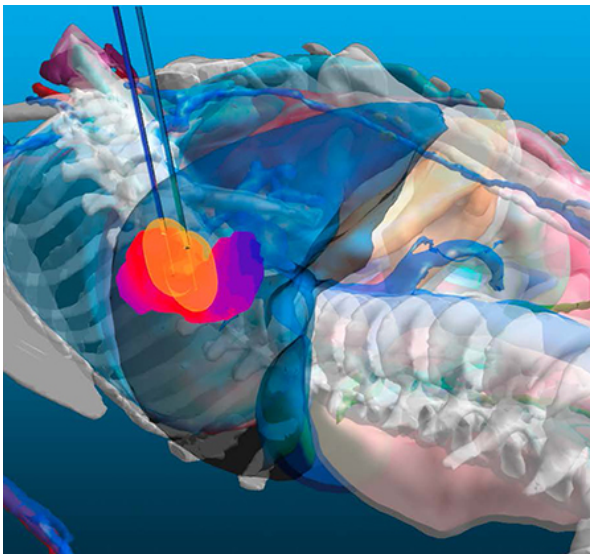






P-THERMAL：Thermodynamics Solvers 热力学解算程序

The Thermodynamic Solvers (P-THERMAL) enable the modeling of heat transfer in living tissue using advanced perfusion and thermoregulation models. The two solvers adapted from SEMCAD X are based on 1) the finite-difference time-domain solver with conformal surface correction and 2) a steady-state finite volume solver to support adaptive rectilinear meshes and arbitrary active domain shapes.



The solvers allow for the coupled simulation of local vascular effects using discrete networks (1D trees) and, in the near future, CFD results.

Exclusive thermal damage and effect quantification models, e.g., T-CEM43, are included.

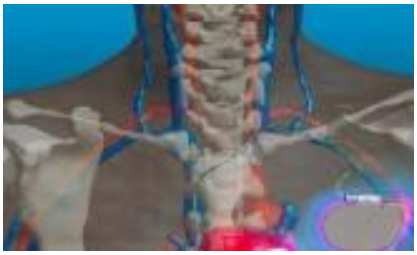
The P-THERMAL solvers have been extensively validated by comparison with analytically solvable cases, experimental measurements under controlled conditions, and in vivo measurements. Comprehensive documentation is available for Sim4Life.

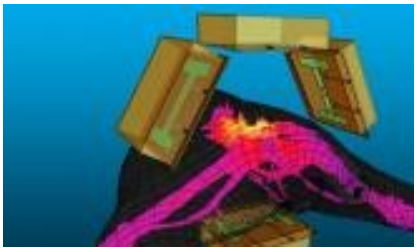
Application Areas

- MRI Tx RF Coil Design w/ Gradient Interaction & Safety
- Active & Passive Implants MRI Safety
- RF Hyperthermia
- Safety & Efficacy Assessment of Ultrasonic Devices for Therapeutic Purposes
- RF/MW Tumor Ablation, RF Surgery
- Design & Optimization of Ultrasonic Devices for Therapeutic Purposes
- MRgFUS Neurosurgery Applications: Tumor Ablation, Neuropathic Pain Treatment, Movement Disorders
- Hypothermia
- Cryosurgery
- Temperature Impact on Neuronal Dynamics
- Flow in Eye (oxygenation, heating)
- Local Cooling by Blood

Key Features

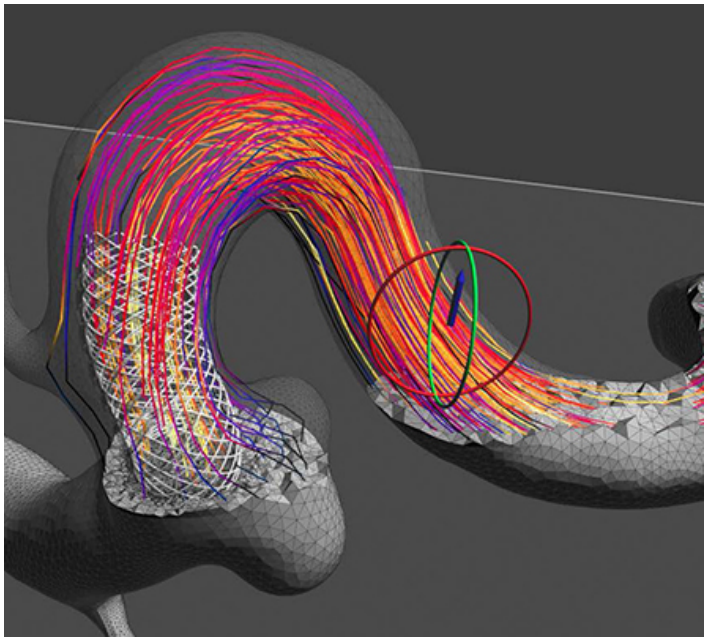
- T standalone solver
- Coupled EM-T, extended Pennes Bioheat Equation for BioEM
- Discrete vessel model for BioEM
- Steady state T solver
- Multiple EM sources (not bound to single simulation)
- Correlated/uncorrelated superposition of fields, individual scaling
- Pulsed excitation/time profile, on-off switch
- T dependent tissues (electric conductivity, SAR, blood perfusion)
- Time dependent specific heat generation rates
- Tensorial heat diffusion
- Spline-based vessels
- Conformal subcell T solver
- Flexible boundary-conditions (Neumann, Dirichlet, mixed, for every interface and every direction)
- Extended T solver functionality (field optimization extended features)
- Thermal ablation (tissue damage) measure
- Convective flow term
- LF solver results as T sources
- Field statistics for T results





P-FLOW：Fluid Dynamics Solvers 流体动力学解算程序

The high performance computing enabled Fluid Dynamics Solvers (P-FLOW) facilitate the modeling of realistic physiological and pathological biofluidic scenarios in the presence and absence of vascular implants. The stationary and transient Navier-Stokes and Stokes equations are efficiently solved in parallel using a Schur-complement-preconditioned finite element method with runtime solver monitoring, advanced convergence criteria, adaptive time-stepping, tunable stabilization, and optional nondimensionalization. Watch the demo video!



The P-FLOW solvers feature a unique solution to model strongly-coupled fluid-structure interaction problems for medtech applications, e.g., for pulsating vasculature modeling. (coming soon)

Specialized boundary conditions for realistic blood flow modeling (e.g., developed flow) and initial conditions based on measured image data can be applied.

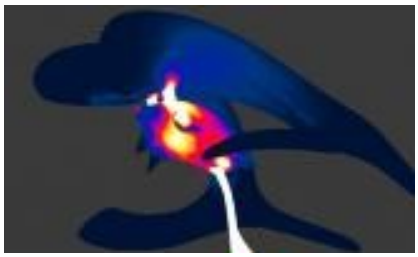
The solvers are comprehensively and continually validated by comparison with analytical solutions for selected problems, benchmark problems, and measurement data. Comprehensive documentation is available for Sim4Life.

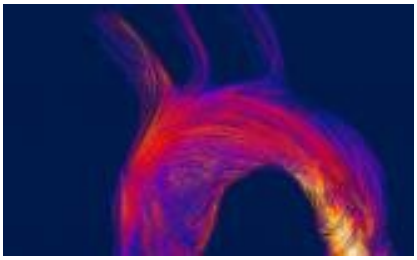
Application Areas

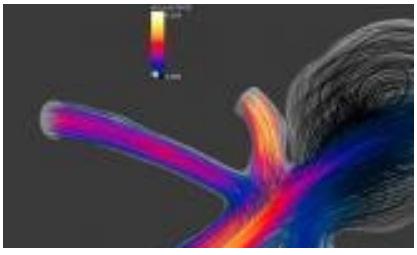
- Magneto-hemodynamics
- Stent Design & Deployment
- Blood Flow (e.g., aneurysm, stenosis, plaque, bypass)
- CSF Flow (e.g., brain shunt)
- Physiological & Pathological Biofluidics Scenarios w/ & w/o Vascular Implants in Complex Geometries
- Microfluidics (diagnosis)
- Kidney Flow
- Microscale Flow in Bones
- Flow in Eye (oxygenation, heating)
- Local Cooling by Blood
- Air Flow (breathing, aerosol transport)

Key Features

- Navier-Stokes & Stokes models (laminar flow of incompressible, Newtonian fluids)
- Parallelized Schur-complement-preconditioned finite element method
- Suitable for the modeling of, e.g., vascular flow, cerebrospinal fluid, respiration, and urinary flow
- Optimized for biomedical flow in realistic geometries
- Flow in stented vessels, bypasses and shunts
- Efficient meshing of complex domains
- Advanced convergence analysis
- Adaptive time-stepping & tunable stabilization
- Specialized boundary conditions for realistic blood flow modeling (developed flow, Windkessel model)
- Boundary & initial conditions from measured image data
- Customizable transient modulation of boundary conditions

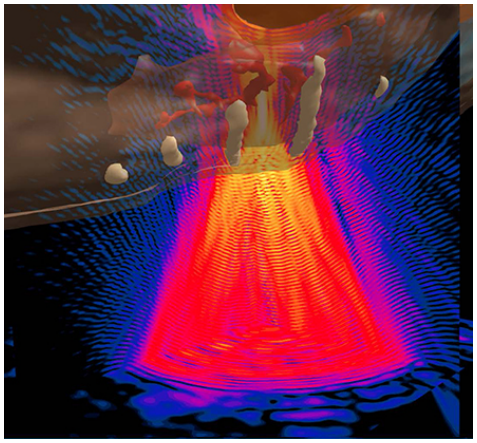






P-ACOUSTICS：Acoustics Solvers 声学解算程序

The two full wave Acoustics Solvers (P-ACOUSTICS) encompass 1) a GPU and OpenMP accelerated non-linear FDTD method with an extended Westervelt-Lighthill equation applied to adaptive rectilinear meshes with inhomogeneous PML boundary conditions and 2) a fast near-field method combined with the hybrid angular spectrum approach (FNM-CHASM) to simulate complex wave propagation inside inhomogeneous tissue distributions and to rapidly calculate pressure distributions for applications such as focused ultrasound treatments. This is state-of-art in computational acoustics.



The novel ultrasound solvers account for pressure wave propagation, density variations and jumps, non-linearity, and diffusivity losses that occur in human tissue.

The FNM-CHASM solver offers near real-time simulations of acoustic propagation in inhomogeneous setups.

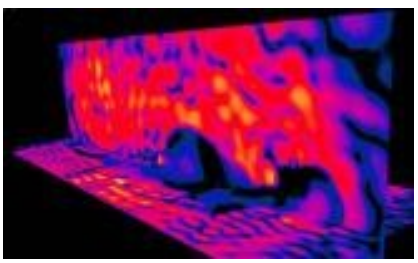
The P-ACOUSTICS solvers have been extensively validated and the associated uncertainties have been quantified using analytical solutions, benchmarks, and robotic 3D-scan hydrophone measurements in complex setups. Comprehensive documentation is available for Sim4Life.

Application Areas

- Safety & Efficacy Assessment of Ultrasonic Devices for Therapeutic Purposes
- Design & Optimization of Ultrasonic Devices for Therapeutic Purposes
- FUS-Based Bbb Disruption for Increased Delivery of Neuro-Active Agents
- FUS-Based Thrombolysis
- FUS-Based Neural Stimulation
- MRgFUS Neurosurgery Applications: Tumor Ablation, Neuropathic Pain Treatment, Movement Disorders
- Sound Exposure (e.g., in MRI)

Key Features

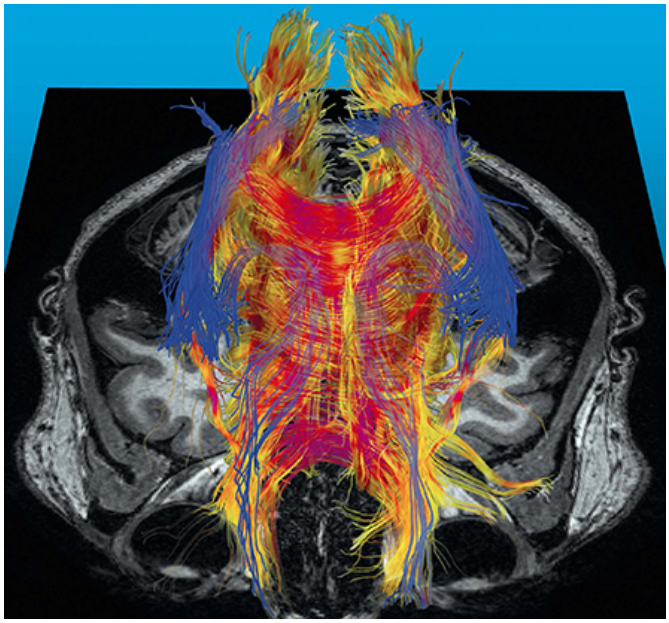
- Linear & non-linear 3D full-wave solvers based on the Westervelt-Lighthill equation (expanded with density variation terms to account for the presence of bones & strongly reflecting material)
- Novel hybrid solver combining the fast near-field method (FNM) & the hybrid angular spectrum method (hASM) allowing for near real-time simulations of setups involving ultrasonic transducers with a principal propagation direction
- Multi-core and GPU acceleration (fastest ultrasonic solver on the market)
- Applicable to both audible acoustics and therapeutic ultrasound simulations
- Coupled with the thermal solver to calculate temperature increases induced by deposited acoustic energy
- Tailored to the simulation of entirely heterogeneous simulation domains
- Capable of simulating entire therapeutic FUS setups involving large anatomical models in minutes
- Tailored to the simulation of large ultrasonic arrays comprising hundreds to thousands of piezoelectric elements
- Enables simulations with arbitrarily shaped transducers & arrays
- Equipped with inhomogeneous PML modules, allowing for domain truncation through an inhomogeneous anatomy, thus restricting the domain size without the need for excessive padding
- Coupled with automatic tools for beam-forming & focal steering based on analytical solutions, ray tracing, & time-reversal techniques
- Built-in calculation of acoustically relevant quantities (intensity, radiation force, particle velocity, etc.)
- Database of acoustic properties



Tissue Models 组织模型

T-NEURO ： Neuronal Tissue Models 神经组织三维模型

The Neuronal Tissue Models (T-NEURO) enable the dynamic modeling of EM-induced neuronal activation, inhibition, and synchronization using either complex, multi-compartmental representations of axons, neurons, and neuronal networks with varying channel dynamics, or generic models. The solvers are ideal for studying interaction mechanisms, evaluating and optimizing neurostimulating devices, and assessing safety issues.



Embedded geometrical and dynamical representation of neurons (soma, axon, and dendritic tree) generate physiologically functionalized anatomical models. (coming soon)

The SENN model (safety standards) and more complex models can be applied inside whole-body models. The GUI facilitates the integration of other neuronal models from commonly used databases or independently derived models.

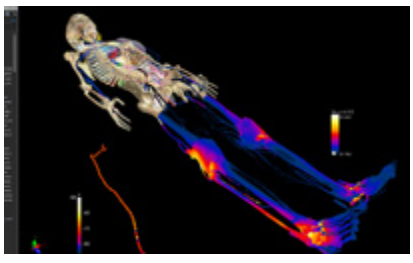
T-NEURO has been validated against published data and ex vivo and in vivo measurements, and is continually advanced and validated.

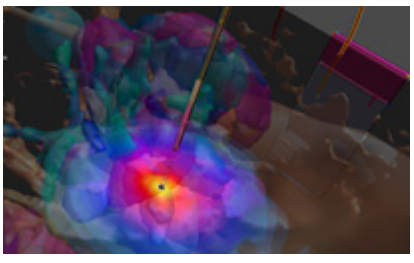
Application Areas

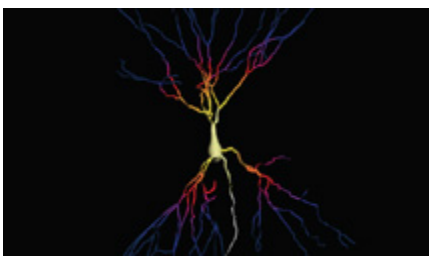
- MRgFUS Neurosurgery Applications: Tumor Ablation, Neuropathic Pain Treatment, Movement Disorders
- FUS-Based Neural Stimulation
- Neuro-Prosthetics (retina, cochlea, vestibular, motor)
- EM Neuro-Stimulation
- Neuro-Motoric Incapacitation
- High LF-EM Field Safety Assessment (e.g., MR Gradient Coils)
- Pacemaker
- Temperature Impact on Neuronal Dynamics

Key Features

- Dynamic modeling of EM-induced neuronal activation inhibition & synchronization
- Unidirectional coupling with the EM-QS and Thermal solver
- SENN model can be applied inside whole body models
- Interface allows integration of other neuronal models from commonly used databases
- User-friendly import & visualization of nerve geometries from commonly used databases
- Determining thresholds through titration procedure
- Detection of neuronal spikes and their occurence times
- Novel spatially varying temperature dependence impact on the neuronal dynamics
- Capturing & plotting membrane dynamics over time
- Easily define pulse sources that correspond to gradient switching fields



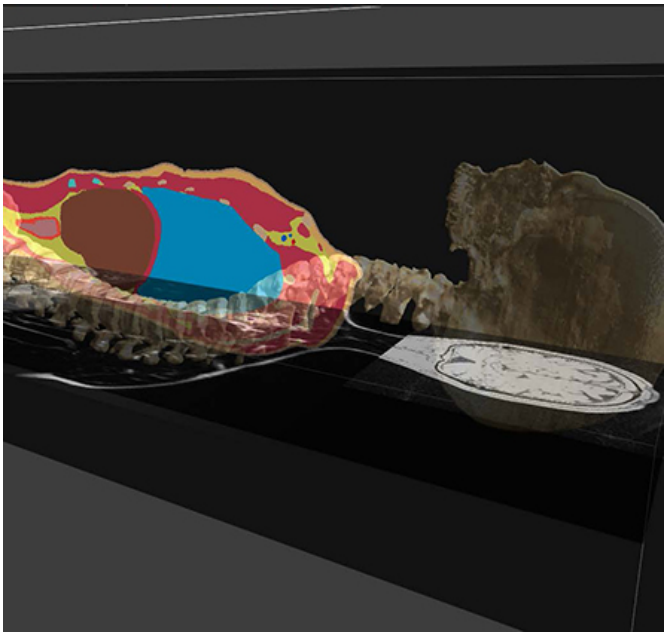




Framework - Intuitive GUI and Workflow 直观的图形用户界面及集成平台

iSEG ： Medical Image Segmentation Tool Set 医学图像分割工具集

The Medical Image Segmentation Tool Set (iSEG) is a fully integrated segmentation (including pre- and postprocessing) toolbox for the efficient, fast, and flexible generation of anatomical models from various types of imaging data. A wide selection of segmentation methods, including competitive region growing approaches, fuzzy connectedness analysis, level-set methods, topologically flexible interpolation, and dedicated vasculature segmentation, ensures the efficient and flexible generation of surface models.



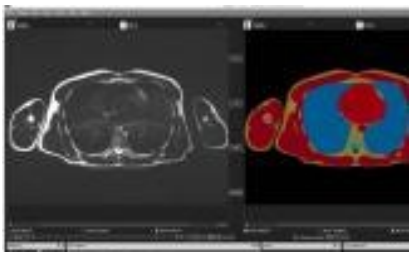
iSEG features a unique set of novel flexibly combinable (semi-) automatic and interactive segmentation algorithms, e.g., to optimize the generation of models with many different tissues. Anatomical reference atlases are also available.

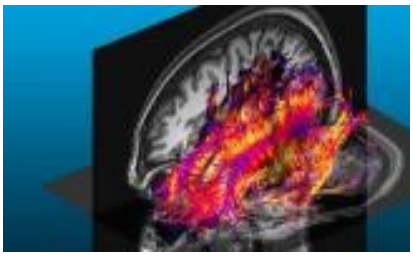
Capable of handling a variety of image data (CT, MRI) and large-scale models.

iSEG offers unique possibilities for medical diagnosis/ treatment and basic research applications, e.g., for personalized modeling and treatment planning, or to investigate physical and physiological processes in realistic anatomical environments.

Key Features

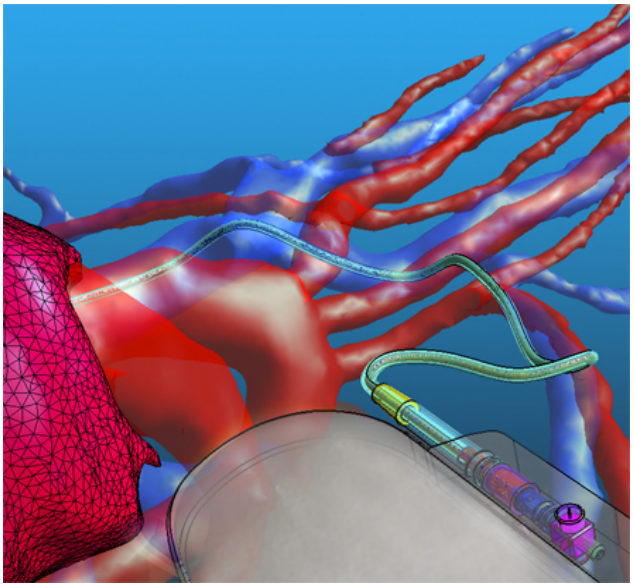
- Fully integrated image segmentation toolbox
- Efficient, fast & flexible generation of anatomical models
- Compatible with all common CT & MRI image formats available
- Various segmentation methods: competitive region growing approaches, clustering, live-wire delineation, fuzzy connectedness analysis, level-set methods, etc.
- Dedicated vasculature segmentation approaches
- Topologically flexible interpolation for accelerated segmentation
- Flexible combination of interactive & automatic segmentation algorithms
- Including anatomical reference atlases
- Enabling personalized modeling & treatment planning
- Supporting large data-sets
- Image pre- & postprocessing (noise removal, masking, filtering, image math, image transformations, skin adding, hole/gap removal, smoothing, morphological operations, etc.)
- Feature analysis, edge extraction, connected components, measurements (areas, volumes, distances, angles, torsion)
- Advance surface extraction & processing (smoothing, simplification) available in Sim4Life
- Surface generations produces conforming, topologically compatible, high quality triangle surface meshes ideally suited for volume mesh generation
- Hierarchical tissue organization, support for multilayer segmentation
- Advanced 3D rendering





MODELER：Advanced Modeling Tool Set 高级建模工具集

Sim4Life integrates a powerful parametric 3D modeling environment based on the ACIS toolkit for generating advanced interactive CAD models and high quality surface models from segmented image data, for example. The fast OGL- and VTK-based rendering engine allows interactive visualization of large and complex volumetric data sets and CAD models. Specialized tools will be continually provided upon user request to handle specific tasks, such as vasculature modeling and processing.



Provides integrated, advanced, and interactive CAD modeling without the need for a preprocessor or live-link; and handles complex anatomical models, e.g., ViP models and massive CAD models.

The only simulation software capable of converting triangular surface meshes into parameterized CAD models, e.g., NURBS-based.

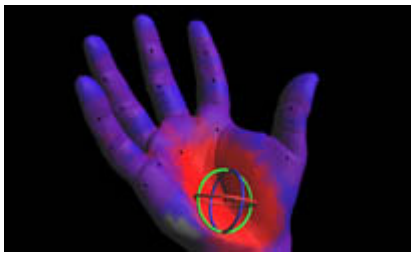
Offers integrated functionality to extract, smooth, and simplify tissue and organ surfaces from segmented medical image data.

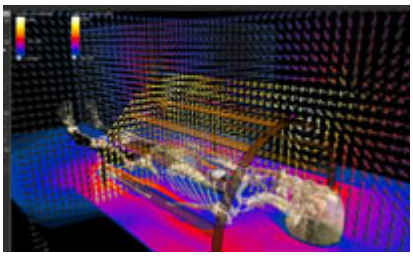
Key Features - Modeling

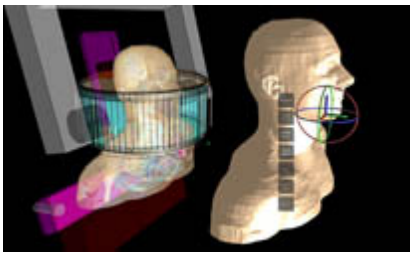
- 3D modeling environment (based on the ACIS toolkit)
- OGL & VTK-based renderer (easy handling of >> 10'000 parts)
- Topological Morphing for conformal 3D modeling to arbitrary surfaces
- Interactive CAD modeling (no preprocessor or live-link needed)
- Modeling units: metric, imperial
- User-guided and/or CAD import-based modeling
- Adjustable transparency, shaded/facet views, etc.
- Drag & Drop for quick moving between groups and objects
- 3D spatial or 2D planar modeling
- Perspective visualization mode
- Mouse, snapping & key-based input, vertices for facilitated modeling
- Predefined 2D & 3D objects (incl. helix, etc.)
- Fully parametrized modeling
- Sweeping, extruding, skinning, rotating, etc. of objects
- Translation, rotation, scaling, mirroring, etc.
- Tilted Lumped elements, Sources & Sensors
- 3D arbitrary object array generation
- Python scripter for generation of arbitrary objects (analytical, etc.)
- CAD derived parametrization
- Localized CAD element modeling
- Boolean operations on CAD objects
- Poser Tool with natural joint rotation limits
- Parametrized birdcage builder with tuning capacitors
- Capable of converting triangular surface meshes into parameterized CAD models (e.g., NURBS-based).
- Functionality to extract, smooth, and simplify tissue/organ surfaces from segmented medical image data

Key Features - CAD

- Import/Export of SAT and SAB files
- Import/Export of IGES files
- Import/Export of STEP files
- Import/Export of 3DS files
- Import/Export of CATIA V4 files and import of CATIA V5 files
- Import of Pro/E files (asm, prt)
- Import of STL files
- Import of I-DEAS files
- Import of Gerber files
- Import of DXF files
- Import of Valor ODB++ files (editable)
- Import of MRI/CT based/segmented files (slices, triangles)
- 3D voxel based data importer, smoothing, compound model conversion segmented, meshes
- VTI, VTP, VTU
- Image data import from iSEG

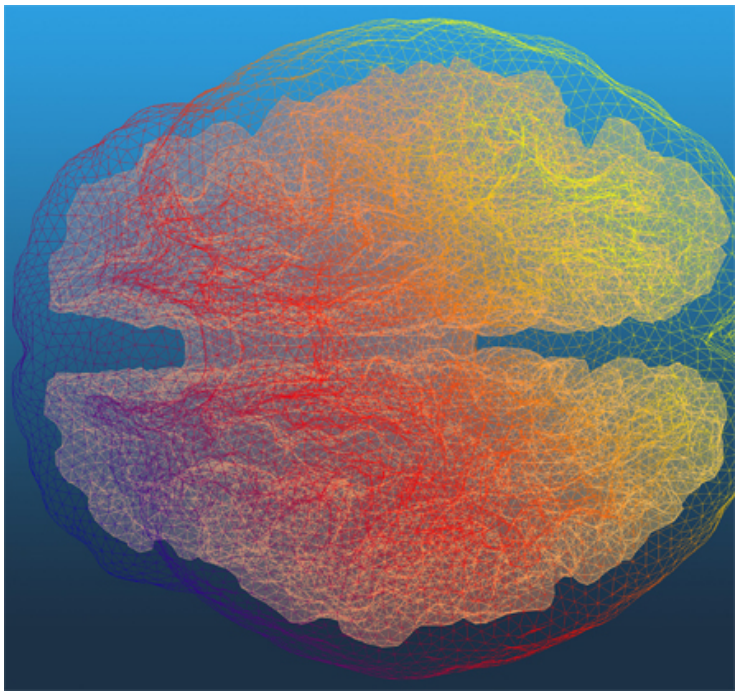






MESHER：Robust & Effective Meshing 强大有效的三维网格

Sim4Life offers a unique array of discretization tools, ranging from the interactive generation of geometrically adaptive rectilinear grids by ray tracing combined with robust intersection testing to Delauney, advancing front, and octree-based methods for unstructured mesh generation in FEM-based solvers. Both irregular anatomical structures and CAD-based models can be handled robustly and flexibly while preserving features.



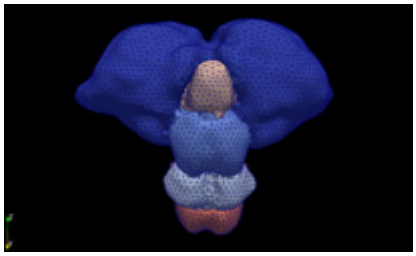
Adaptive, rectilinear meshes (e.g., for P-EM-FDTD, P-ACOUSTICS, P-THERMAL) can be generated interactively with excellent heuristics-based automatic grid generation and flexible tuning.

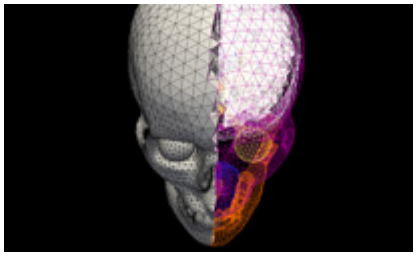
A variety of meshers (e.g., for P-FLOW) capable of generating high-quality element, adaptive, feature preserving, unstructured meshes from CAD data and complex anatomical models are provided. (coming soon)

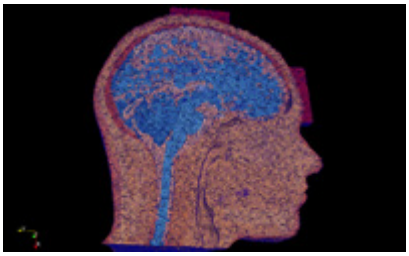
The only surface processing tool capable of producing topologically conforming, high triangle element quality, non-(self) intersecting surface meshes from noisy segmentation data; the ideal basis for unstructured volume mesh generation.

Key Features

- Adaptive, non-uniform meshing (graded)
- Fastest high-speed grid generator, object-analysis-intelligence
- Predefined/customizable grid templates (fast settings assignment)
- New user-friendly & intuitive engine (gang axes / settings simplification)
- Voxel connectivity check for PEC/metal connectivity verification
- Specifically tailored meshers for Yee-FDTD or conformal solvers
- High-level automation (one-click-grid)
- Broad variety of user-defined grid settings
- Real-time object selective gridding
- Geometrical analysis of solids for grid refinement
- GUI-based selection of estimated grid size/simulation time trade-off
- Fast 3D or 2D conformal or Yee mesh viewer
- Region selective mesh visualization (plane, cube, etc.)
- Fully native 64 bit support for large meshes (>> 1 billion cells)
- Variety of tools for editing & preprocessing surface meshes
- Robust conversion of small and medium-sized surface meshes to NURBS models
- Delaunay approach or an Advancing Front method (for computational meshes)
- Specify local mesh parameters (defined on surface regions or sub-regions)
- Mesh quality inspector (several quality metrics, mesh viewer with locating bad/small elements)

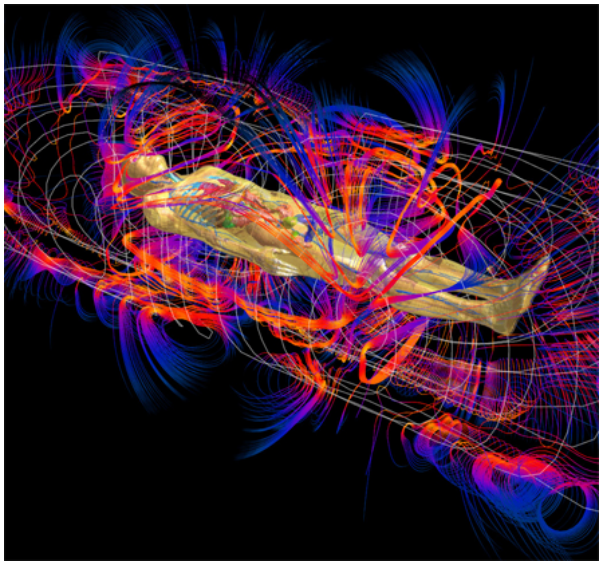






ANALYZER: Versatile Postprocessor & Analyzing Tool Set 通用后处理器和分析工具集

Postprocessing in Sim4Life provides complete insight into intricate simulation results and measurement and imaging data through advanced visualization and analysis capabilities. Viewers tailored for medtech simulations (e.g., volume rendering, streamlines, maximum intensity projection, surface fields on arbitrary 3D structures) and calculators for recurring tasks (resampling, filtering, functional evaluation) on unstructured/structured field data are included.



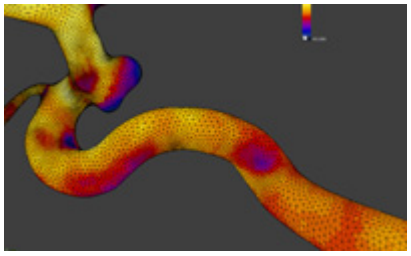
A novel pipeline architecture allows for the setup of complex analysis sequences and simple reevaluations with modified input data or parameters. Analysis steps can be stored in and re-loaded from analysis or visualization "projects".

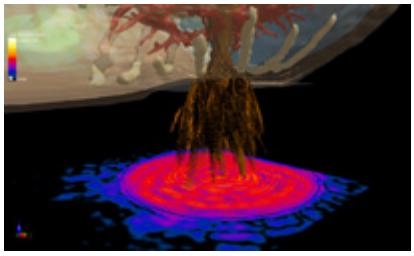
Processing (interpolation, interactive cropping/masking, etc.) and visualization of the simulation results together with the measured/imaging data directly on the models.

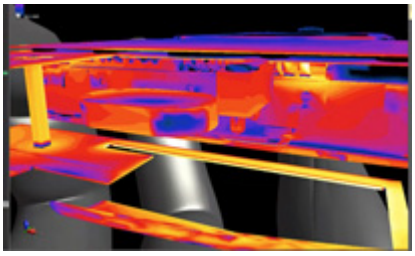
Derived quantities based on any solver results or measurement data can be computed and visualized by maximally exploiting the algorithmic and visualization capabilities of the VTK, including interpolation, DFT, and a generic calculator.

Key Features

- Fast 3D OGL QTech or vtk- based rendering/visualization of result data
- Novel vtk-based pipeline architecture, template pipelines (on-demand driven work/data flow)
- Complex postprocessing steps to be combined or stored as analysis or visualization "projects"
- Supports generic data processing
- Unstructured/regular field data
- Processing algorithms (filtering, evaluation, etc.)
- Interactive, control directly via 3d window
- 2D & 3D view, animations
- Volume rendering on GPU, streamlines, maximum intensity projection, interpolation on arbitrary 3D structures, surface field rendering, etc.
- Calculators, processing algorithms (resampling, filtering, evaluation, cropping)
- Generating model objects, e.g., at special features of the field which can be used for grid refinement, sensors, reference points, etc.
- Improved 2D XY plots, polar plots, Smith chart
- Radiation pattern (3D in model, 2D XY/polar)
- EM fields (Avg P, B, D, E, H, J, S, Energy, etc.)
- Radiation & far-field data, efficiency, TIS, TRP, Radar Cross-Section
- SAR/absorption (Av. 1g/10g/arbitrary IEEE1529, distributions, dP/dV)
- Full multi-port S-Parameter extraction
- Solid/material selective extraction/processing
- User-oriented Line Field Extraction tool
- Statistics processing, visualization & extraction into tables
- 3D viewers (2D planar slice, overlay on surfaces conformal/Yee, vectors/arrows, ISO surfaces, etc.)
- Novel 3D vector & streamline viewers
- Combination/comparison & visualization of multiple results
- Overlaid visualization of model/voxels/results
- Fast handling of 64 bit results (>> 1 billion voxels, native 64 bit)
- Full Python scripting engine support (interfacing of all features)
- Data processing in time & frequency domains
- Data export into 3rd party editors
- Viewer exports to image data
- Automatic Cache Save/Load extracted results

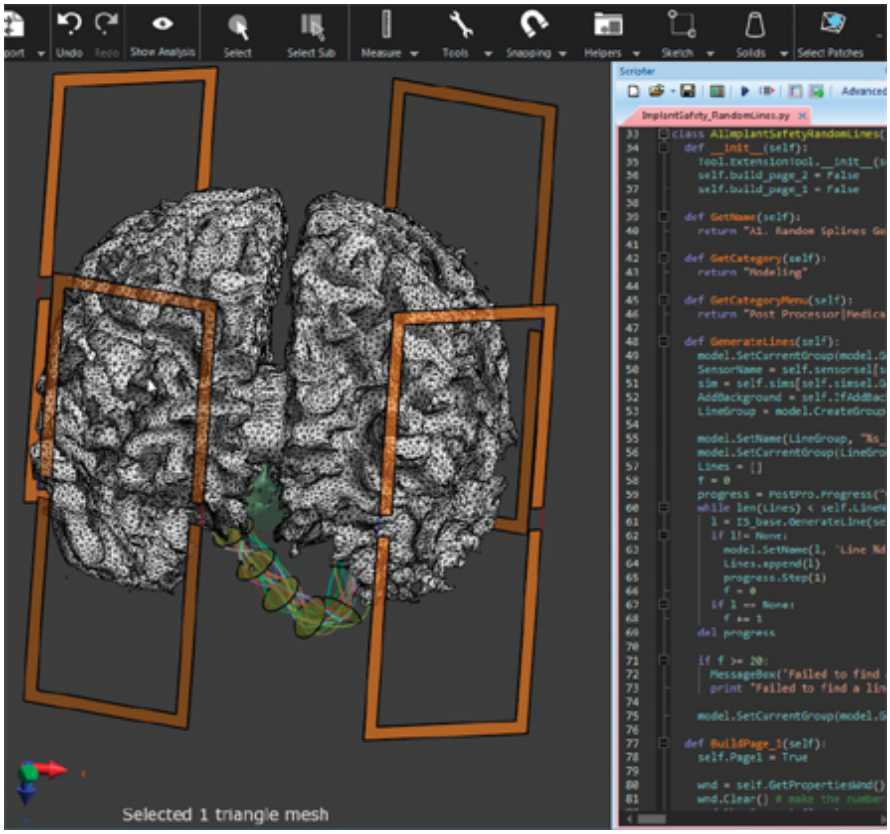






PYTHON: Control via Python Scripting 通过解释型计算机程序设计语言 Python Scriptin 控制

Sim4Life features Python, a powerful scientific scripting language offering a vast range of third-party programs. The Sim4Life Python application programming interface (API) can be used to parameterize and automatize tasks, e.g., geometric modeling, simulation setup, or postprocessing, and to build custom tools and independent applications.



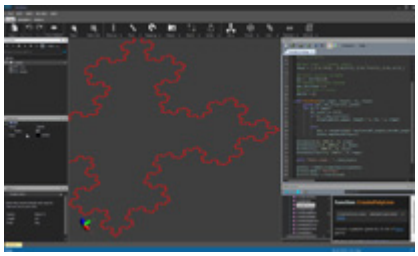
A Python scripting environment and a wide selection of powerful libraries, such as SciPy, NumPy, and pandas, are embedded in Sim4Life, and additional packages from online repositories can be installed with the package manager.

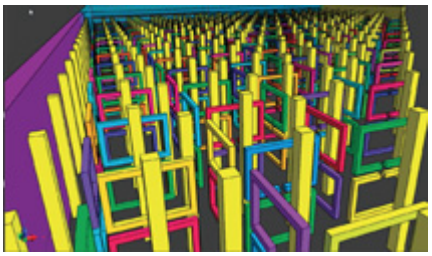
Various easy-to-use Python routines for performing frequent tasks and an extensive API for deep access to the Sim4Life framework are provided.

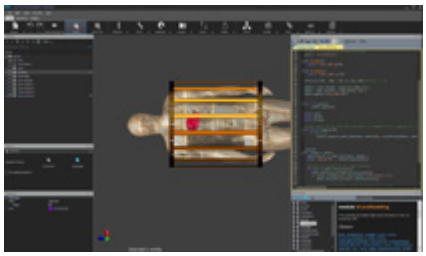
The straightforward Python API is fully customizable: Create and sell individual licensed modules to the Sim4Life user community.

Key Features

- Python densely/smoothly embedded into *Sim4Life*framework
- Scripting function access to all *Sim4Life*features on all levels (modeling, grid, simulation, postprocessing, etc.)
- Integrated Enthought Python package (wide range of powerful libraries, such as SciPy, NumPy, & pandas)
- Fully interfaced scripter for automation, batching, parametrization
- Script editor (with visual support) embedded in GUI
- Enhanced tabbed script editor, with multi-selection file opening
- Python API Browser & automatic API lookup
- Unbounded user customization possibilities (generate a user's own library of tools, build a customized *Sim4Life*environment)
- Launch batch simulations, parametrization, optimization
- Automated extraction of various parameters & result data of interest

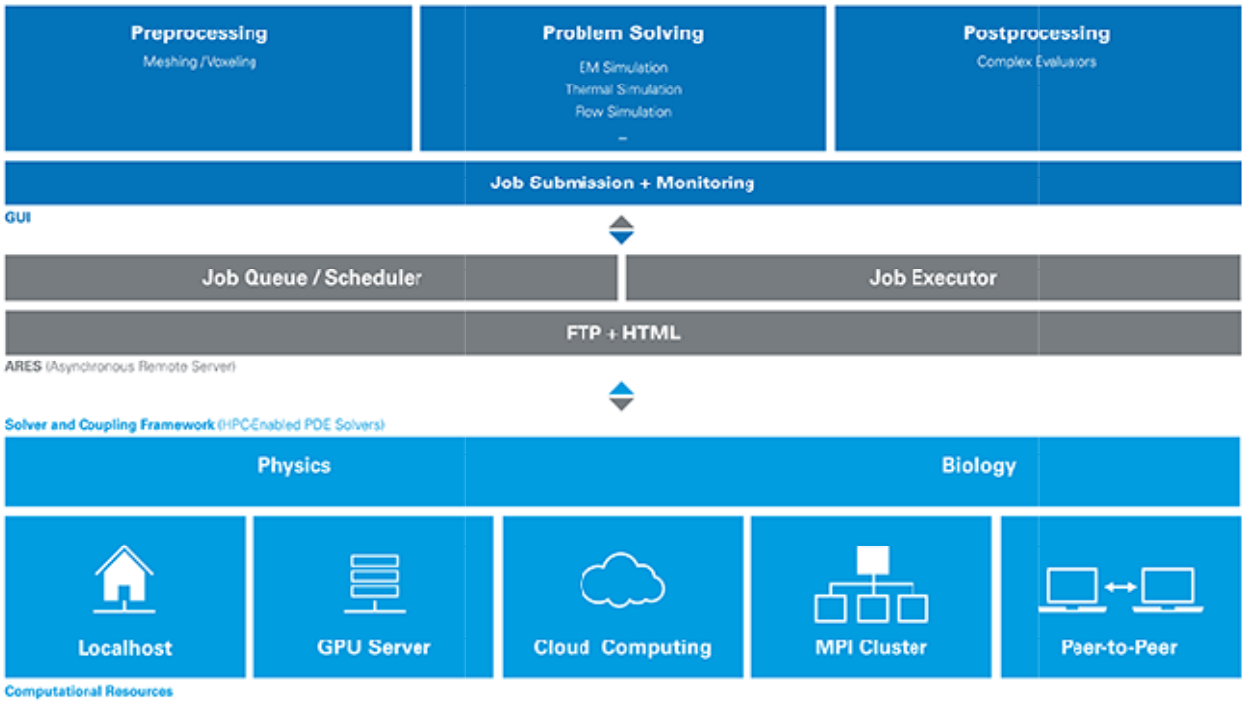






ARES：High Performance Computing Auto-Scheduler & Control　高性能计算自动调度和控制

Sim4Life offers high performance computing to enable the investigation of complex and realistic models. Multi-threaded execution for modeling, meshing, voxeling, and postprocessing enables parallel processing of heavy tasks without disturbing the workflow. A fully integrated centralized task manager efficiently manages all computationally intensive tasks on the local machine or in the cloud.



Sim4Life features the fastest GPU-enabled EM-FDTD and US solvers (P-EM-FDTD & P-ACOUSTICS).
The MPI parallelization-based FEM solver optimally uses multi-core processors, clusters, and supercomputers for extreme performance.
A unified interface supports cloud computing on any of the major providers, e.g., Amazon or Google.

Key Features - Networking

- Fully integrated centralized task manager
- All functionality (remote computing, HPC) seamlessly integrated into *Sim4Life* & Python framework
- Parallel processing of computationally intensive tasks (e.g., meshing, simulation, postprocessing)
- Remote execution via cloud (e.g., Amazon), localhost, GPU server, MPI cluster, p2p, etc.
- Heavily multi-threaded execution for modeling, meshing, voxeling, and postprocessing
- Queuing control instances, statistics
- Solver control via*Sim4Life* GUI
- Intelligent job submission
- Job progress via a web browser (http based) on mobile devices, etc.

Key Features - HPC

- AXE GPU libraries
- ZMT HPC/CUDA libraries
- Cluster-MPI for Linux
- Improved OpenMP parallelization for all of the above mentioned

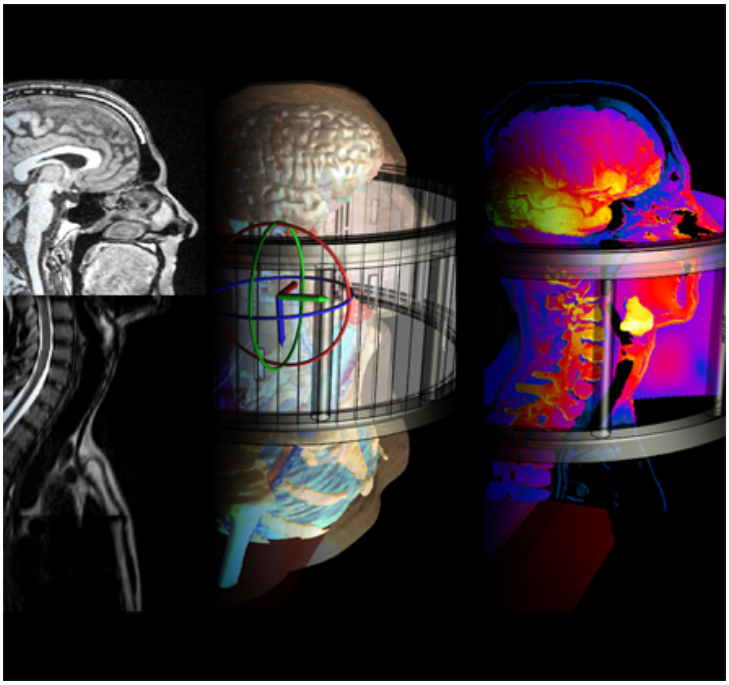
Hardware Acceleration Solutions:

- K20/x - NVIDIA Tesla K20/x
- K40 - NVIDIA Tesla K40
- Servers/Workstations with multiple GPU cards (K20, K20x & K40)

- AXE MPI engine (for multi-CPU/multi-core distributed clusters)

GUI & USABILITY：Intuitive GUI And Workflow 直观的图形用户界面和工作流程

The Sim4Life GUI efficiently facilitates all steps in complex multiphysics modeling, from defining the problem, discretizing, simulating, and analyzing to visualizing the results, with clarity and flexibility. The unobtrusive user interface reduces redundant tasks by presenting a clear overview of the model with context adaptive menus and natural user-interaction paradigms. Dedicated tools are available to further reduce user effort for specialized tasks.



The streamlined user interface minimizes the number of required processing steps.

Supports drag-drop-based assignments and features powerful interactive handling, e.g., in geometric modeling, simulation coupling, and material assignment.

Context-dependent menus, options, and functions optimally streamline tasks.

Key Features - Platform

GUI

- Windows 7, Windows 8/8.1 & Windows 10,
  64 bit
- OSX via Parallels, VMWare

Solvers

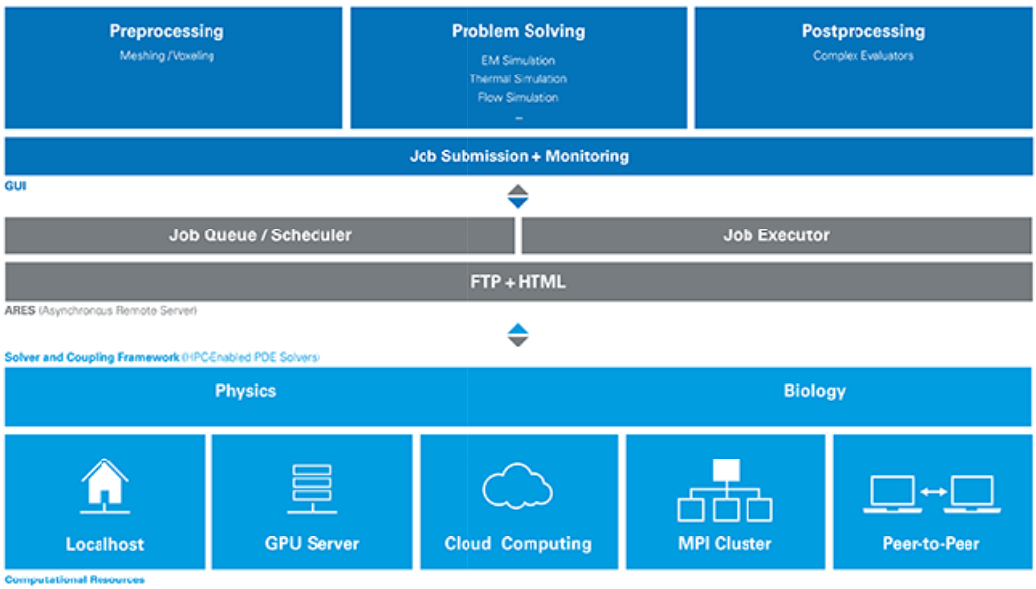
- Windows 7, Windows 8/8.1 & Windows 10
  64 bit
- RedHat 5 Linux 32 bit, 64 bit
- Mandrake, SuSE, Mac OS X, SUN Solaris V8, SG, HP, etc. (all Linux versions on special request)

Key Features - GUI

- Integrated Modeling/ Simulation/Analysis environments
- Drag & drop-based assignments and powerful interactive handling
- Tree-based access to all simulation parts (settings, solids, materials, grids, results, postprocessing, etc.)
- Context dependent menus, options, and functions
- Easy copy-paste of entire simulations or settings parts
- 3D or 2D planar views
- SnagIt® integration for easy image/video capturing
- Selection, zooming, 3-D mouse-only based handling, light rendering
- Calculator tools for various functions
- Fully native 64 bit support (large models, voxel numbers, and results)

HPC：HIGH PERFORMANCE COMPUTING 高性能计算

Sim4Life offers high performance computing to enable the investigation of complex and realistic models. Multi-threaded execution for modeling, meshing, voxeling, and postprocessing enables parallel processing of heavy tasks without disturbing the workflow. A fully integrated centralized task manager efficiently manages all computationally intensive tasks on the local machine or in the cloud. Two sets of CUDA-based libraries for GPU acceleration are provided: Acceleware and ZMT CUDA.



Sim4Life features the fastest GPU-enabled EM-FDTD and US solvers (P-EM-FDTD & P-ACOUSTICS). The MPI parallelization-based FEM solver optimally uses multi-core processors, clusters, and supercomputers to guarantee extreme performance for demanding tasks. A unified interface supports cloud computing on any of the major providers, e.g., Amazon or Google.

Key Features - Acceleware

Advanced libraries for EM-FDTD

Support for dispersive media and lossy metals

Multi-GPU support

Key Features - CUDA

Libraries for EM-FDTD and Acoustics

Multi-GPU support

Key Features - MPI

Libraries for Flow

Supported OS

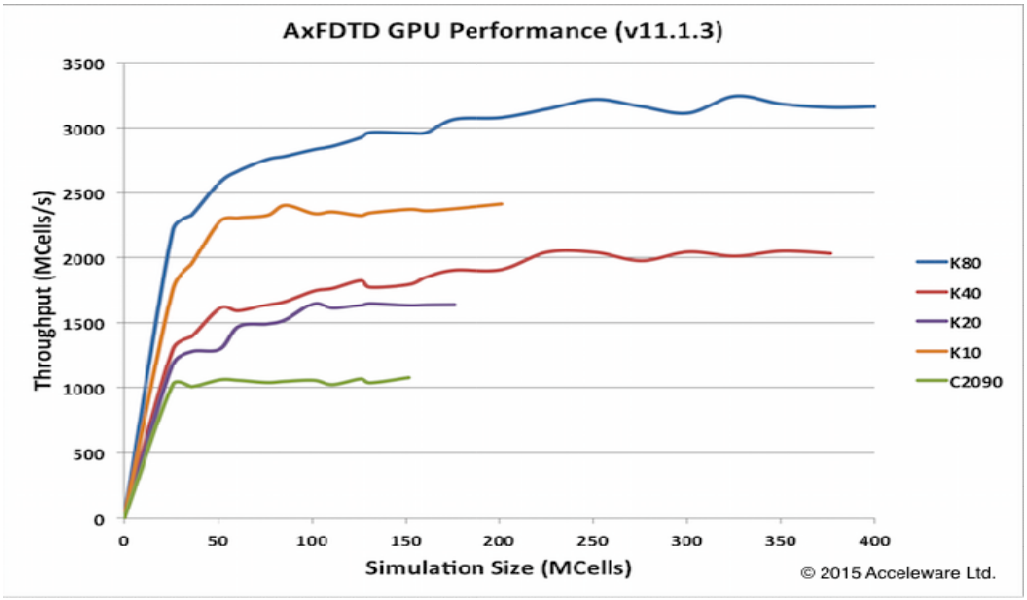
- Windows 7/8/8.1/10
- Windows Server 2008/ 2012
- Linux RedHat 5 and CentOS

GPUs for Workstations

- NVIDIA Tesla K20, K40
- NVIDIA Quadro K6000, K5000
- NVIDIA Tesla C2070/C2070

GPUs for Servers

- NVIDIA Tesla K10, K20/X, K40, K80
- NVIDIA Tesla M2090, M2070, M2050



Any NVIDIA card with CUDA compute capabilities higher than 1.3 can be used, but GPUs from the Tesla series are recommended since they are intended for heavy computation.

Benchmarks I: Small Computational Domain

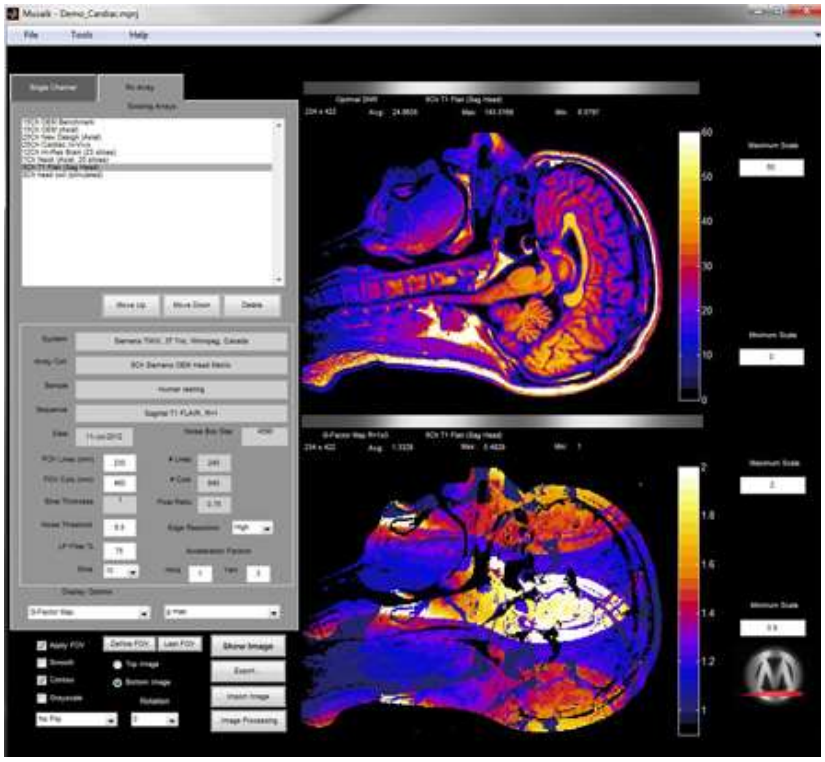
Sim4Life Modules - Licensed Modules 可授权模块

MRI	Modeling	Calculators	Processing	Import
M-MUSAIK	M-REMESH	M-DISFIT	M-MATCH	M-HUYGENS
M-SYSSIM	M-POSER	M-PPCALC	M-TALATLAS	M-IMG
M-BCAGE	M-iSEG		M-MBSAR	M-VOX
M-TxCOIL			M-PHARRAY	
M-GRAD				
M-IMSAFE				

MRI Modules 磁共振三维成像模块

MUSAIK

Framework for MRI receive coil array design, optimization, and performance verification (based on simulation results or experimental data).



Product description

MUSAIK enables the user to import simulation results of array coils and assess their parallel imaging capabilities. Equivalent analysis is available for experimentally obtained data, allowing accurate verification for a range of different design processes or to evaluate simulation model fidelity. The user can evaluate signal-to-noise ratio (SNR) and 2D parallel MRI g-factor maps from simulated and/or experimental datasets.

Features

- 3-D analysis of array coil SNR and g-factor performance
- complex noise correlation matrix calculation
- explore channel compression by combining multiple array elements into a single channel
- export complex composite datasets for dedicated postprocessing
- analyze ratio images to asses regional SNR or g-factor gains
- assess 3-D average or maximum SNR gain for localized ROI
- SNR/g-factor displays to help gauge image quality limitations
- Data converters for Bruker Biospin, GE Healthcare, Philips Healthcare, Siemens Healthcare and Toshiba Medical

Applications

- troubleshoot defective Rx channels and coil isolation
- troubleshoot simulation model accuracy or experimental outputs by comparing equivalent systems
- compare different image reconstruction algorithms
- verify performance of realized coil designs
- study anatomy effects on g-factor

SYSSIM

MRI scanner simulator predicts realistic EM field effects on MR images for arbitrary pulse sequences.

Product description

MRI scanner simulator predicts realistic EM field effects on MR images for arbitrary pulse sequences. Generates simulated MR images with realistic signal, contrast, noise, and SAR values considering B0 and fields from both transmit and receive arrays

Features

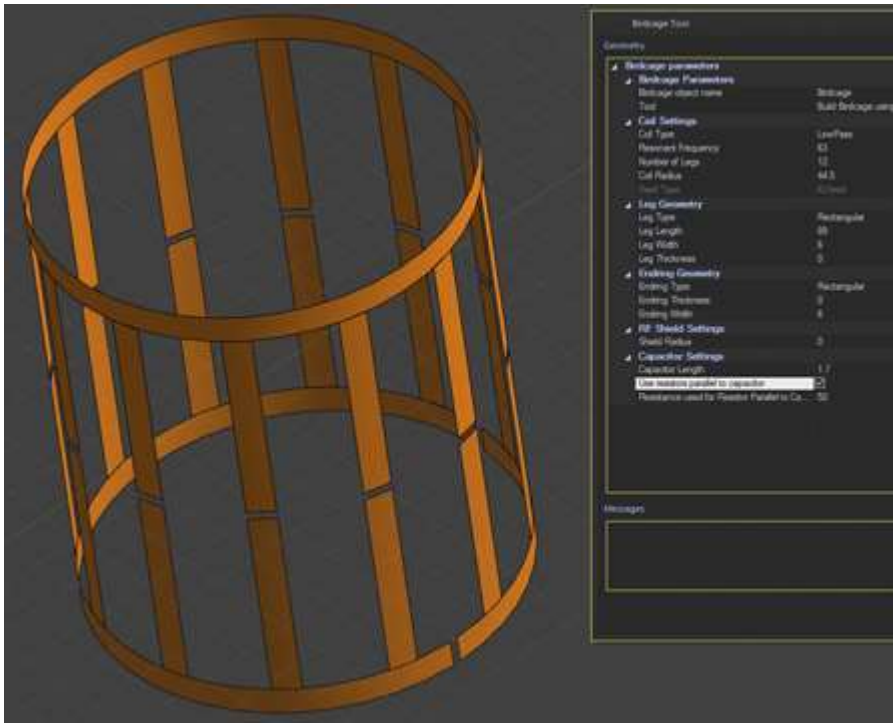
- Calculates k-space, signal & noise (SNR), time-average SAR distribution and resulting MRI images for user-defined reconstruction techniques based on
- B1+/- and E fields (RF coils), gradient fields, and Bo field distributions from Sim4Life
- tissue geometry with electrical properties and MR properties (T1, T2, proton density, chemical shift,...etc.) including IT'IS ViP models
- MR pulse sequences (GRE, SE, EPI) and sequence parameters (pulse shape, duration, flip angles, TE, TR, etc.)

Applications

- Optimization of pulse sequences to overcome or compensate for imperfections in the field distributions due to field/tissue interactions (e.g. implants or tumors) or design constrains
- Enables engineers, physicists or radiologists without an MRI scanner to simulate the scanner for TX, RX and imaging performance.

BCAGE

Parameterized MRI volume coil designer for birdcage coil geometries and associated simulation settings.



Product description

Interactive tool to create birdcage-style volume coils following user design parameters such as dimensions, operating frequency, feeding and coil topology.

Features

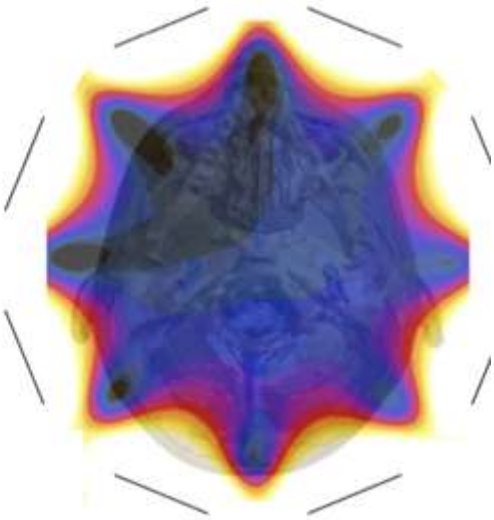
- generate coil geometry
- placement and calculation of lumped elements for tunning
- create template simulation with proper settings, materials and grid

Applications

- birdcage coil design for Tx and Rx
- easy design of generic volume Tx coil for implant compatibility

TxCOIL

Parallel transmit coil design and optimization post processing engine.



Product description

TxCOIL enables the user to perform RF shimming on parallel transmit coils to improve field homogeneity and calculate the combined SAR in post processing without rerunning the simulations.

Features

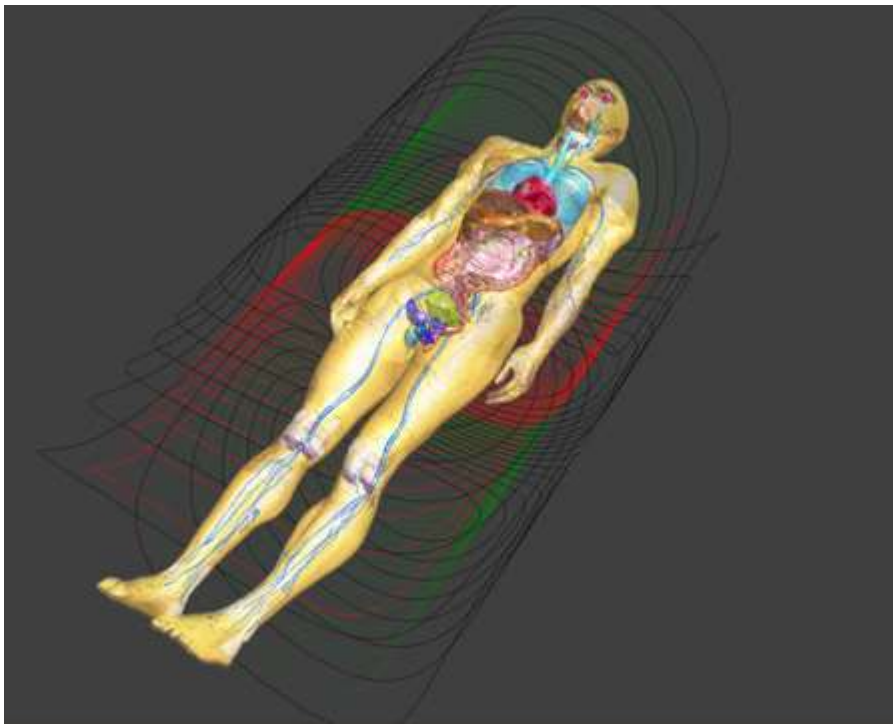
- Field combiner for B1 shimming
- Active and passive ports (load, open or short circuit)
- User defined ROI with 3 levels: sensor, object and subregion
- Dosimetry analysis of the resulting combined fields
- Worst-case SAR calculation

Applications

- OB1 field homogenization
- Compare multiple excitation schemes to select the most suitable one, taking into account total SAR

GRAD

MRI Gradient coil designer and optimization engine (considers interactions with present scatterers, e.g., patients/implants and RF coils).



Product description

MRI Gradient coil designer and optimization engine (considers interactions with present scatterers, e.g., patients/implants and RF coils).

Features

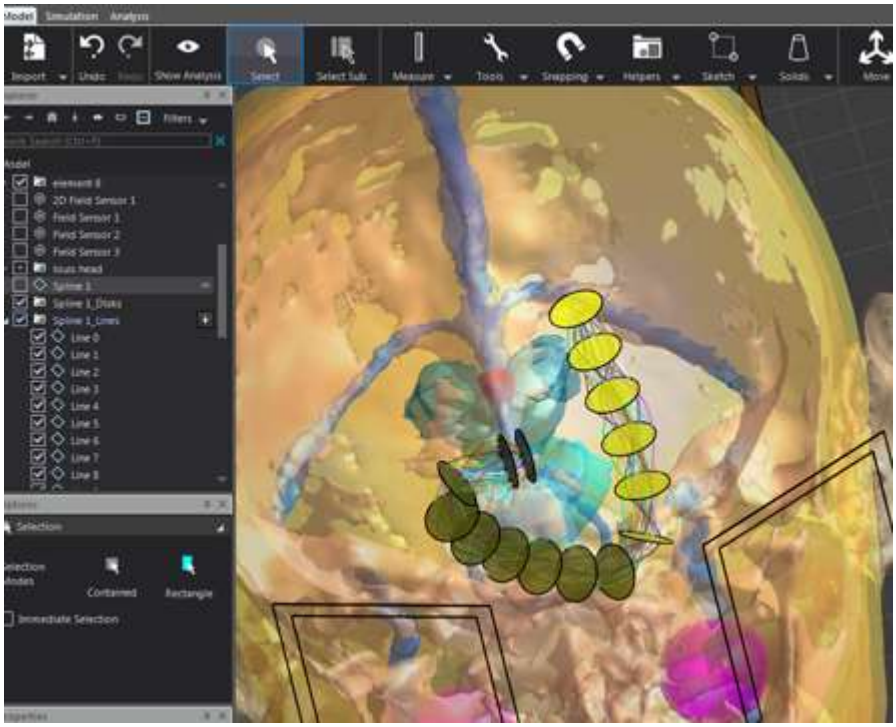
- take into account uniform or realistic B0 distribution
- optimize current density and field homogeneity, minimize power and inductance

Applications

- design arbitrary shaped gradient coils
- calculate interaction (Eddy currents) in between gradient fields and other elements like gradient shielding, RF coil and shield, implanted devices inside the patient
- Gradient coil safety evaluation with and without implant (nerve stimulation, vibration …)

IMSAFE

Intuitive 4-step procedure supports Tier 3 (from the „4 Tier Approach“ developed by JWG for AIMD ISO/IEC).



Product description

IMSAFE helps to evaluate RF MRI safety of elongated medical devices inside the human body. Following Tier 3 from the “4 Tier Approach” developed by the JWG.

Features

- easy placement of arbitrary lead trajectories inside the volume defined
- batch processing of tangential E field along the trajectories

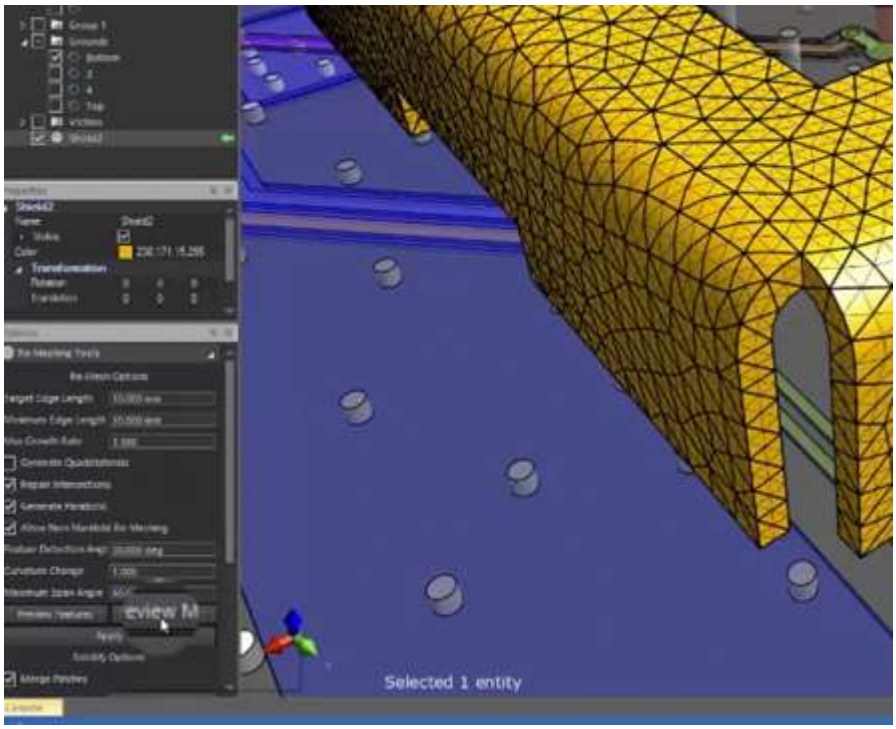
Applications

- RF MRI safety analysis for elongated medical devices

Modeling Modules 三维模拟模块

REMESH

Modeling tool to edit meshes to refine or simplify them following user-defined adjustments.



Product description

Mesh editor to refine or simplify meshes following user-defined adjustments.

Features

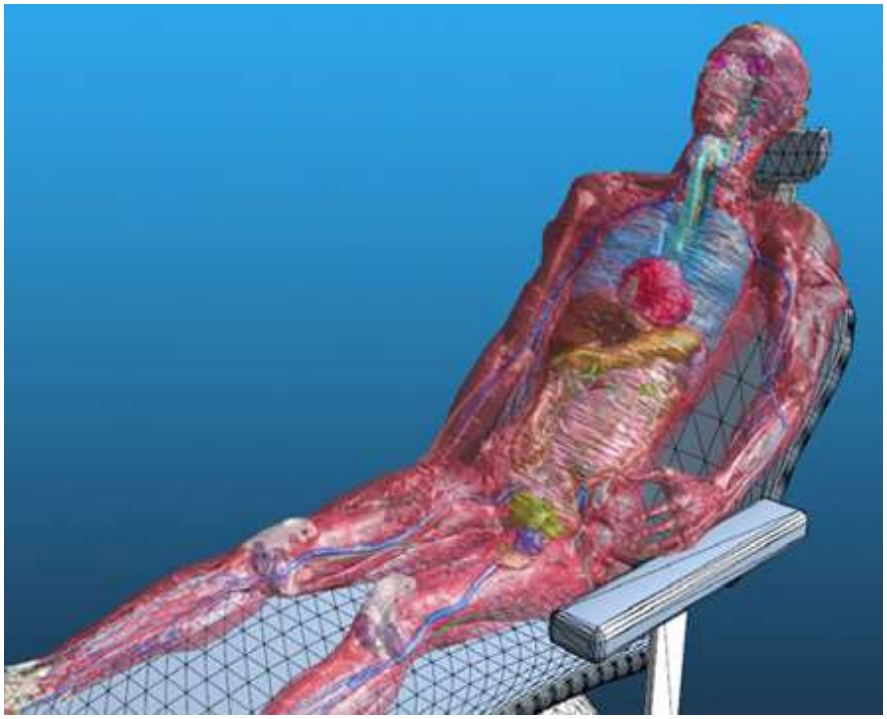
- repair and healing
- robust conversion to solid
- mesh refinement
- VKI based

Applications

- mesh refinement for accurate processing
- mesh simplification for lighter handling

POSER

Poser tool that manipulates the ViP models (3.0 or higher) to a desired position (volume preserving, influence regions).



Product description

Poser tool that manipulates the ViP models (3.0 or higher) to a desired position (volume preserving, influence regions). It deforms the underlying rigid skeleton by specifying the required orientation at the articulated joints. Novel techniques allow deformations to be smoothly visualized in real time. Rapid switching between pre-saved (and user-defined) postures can be performed.

Features

- based on techniques developed for animation pictures features
- easy articulation of joints in their physiological ranges
- deformation of the soft tissue without loss of connectivity and without changes in the total tissue volume
- predefined postures for standing, sitting and lying persons

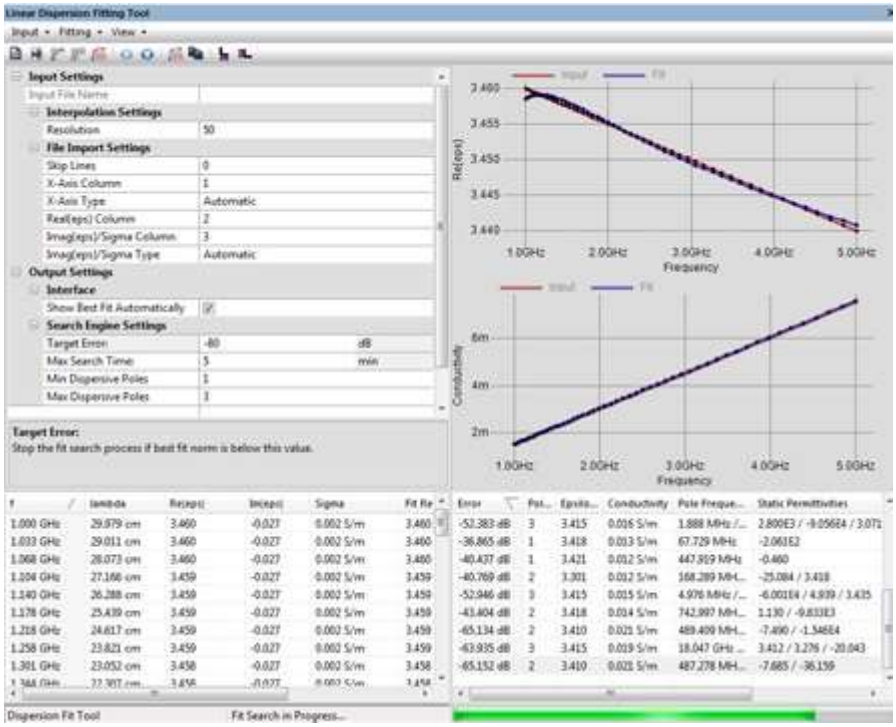
Applications

- exposure evaluations in real situations, such as work places, and device optimization, e.g., hand-held devices, body-mounted or implantable devices

Calculators Modules　计算模块

DISPFIT

Dispersive fitting tool based on GA optimization.



Product description

Genetic Algorithm based optimization tool to obtain parameters for the different dispersive models (Debye, Lorentz, Drude, and the combination of Drude-Lorentz) for a given material (user-defined or imported from a text file).

Features

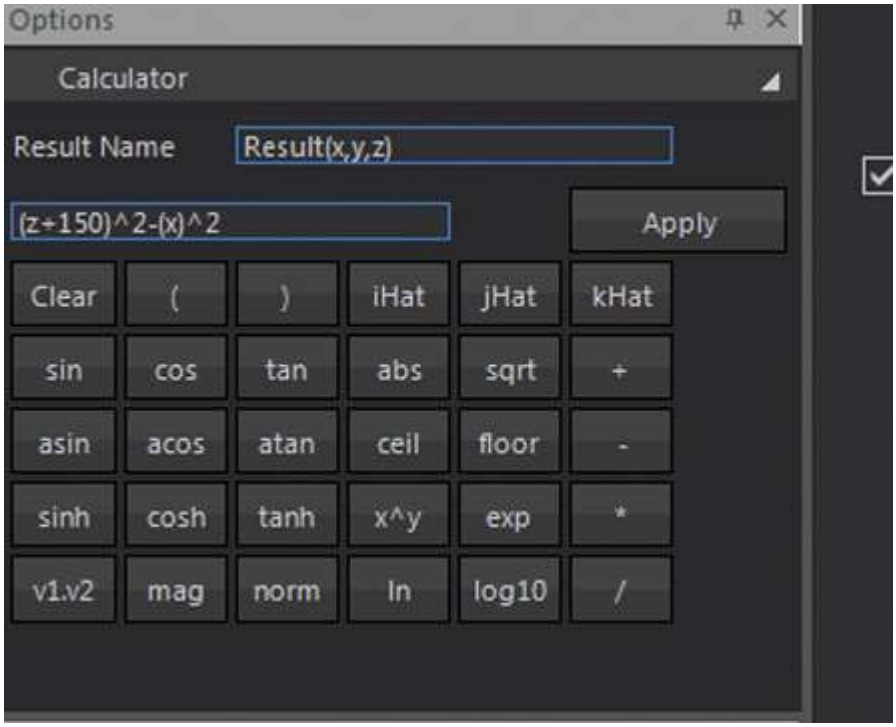
- initial data can be loaded from text file or specified directly by the user
- load IT'IS material database
- specify initial and final frequency and number of samples
- specify target error, maximum search time and number of poles
- graphic representation of initial data and proposed fitting curves superimposed
- X-axis can display frequency or wavelength
- Y-axis can display Conductivity or Imaginary part of Permittivity
- Best fit can be copied directly into simulation settings

Applications

- obtain frequency dependent material parameters for wideband simulations

PPCALC

ntegrated Pipeline/Analysis Calculator.



Product description

An integrated Pipeline/Analysis Calculator enables calculations of any simulated values/distributions, normalization, etc.

Features

- calculation/display of any performance data
- creating a Calculator as a child of another Calculator
- various math functions available
- direct variable access
- database of physical constants
- integrated into GUI or standalone (floating, docked)
- embedding into analysis or visualization “projects”

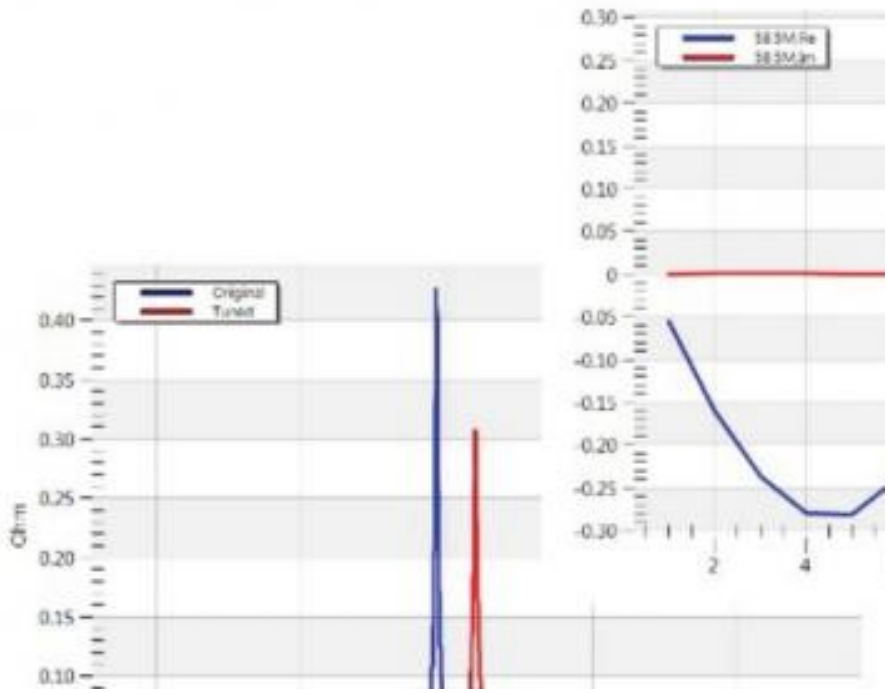
Applications

- smoothly embedded into pipelining and thus applied to all applications

Processing Modules　处理模块

MATCH

Versatile matching circuit application.



Product description

Versatile matching circuit application for multiport devices, such as RX/TX MR coil or antenna arrays.

Features

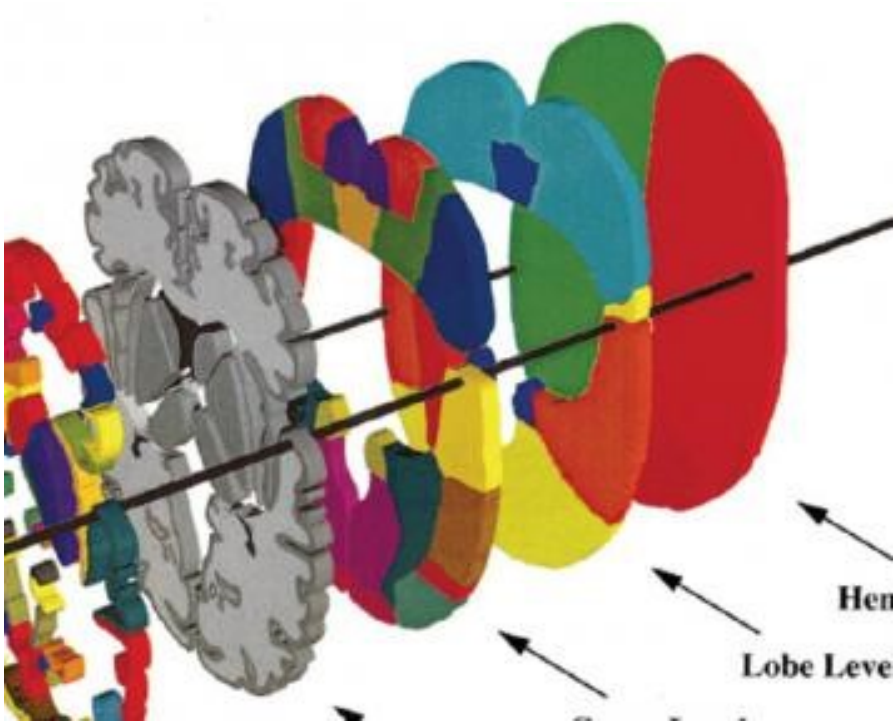
- input date from MultiPort Simulations or Touchstone files
- create new settings or load existing ones
- specify ports and loads
- select matching circuit type (T, pi, none) and order
- plot or export resulting S matrix

Applications

- matching of antennas and antenna arrays
- matching of RF array coils

TALATLAS

Automatic identification and hierarchical labeling of brain/substructures.



Product description

Automatic identification and hierarchical labeling of brain/substructures, e.g., for the characterization of the electromagnetic exposure of the brain (>1000 different sites).

Features

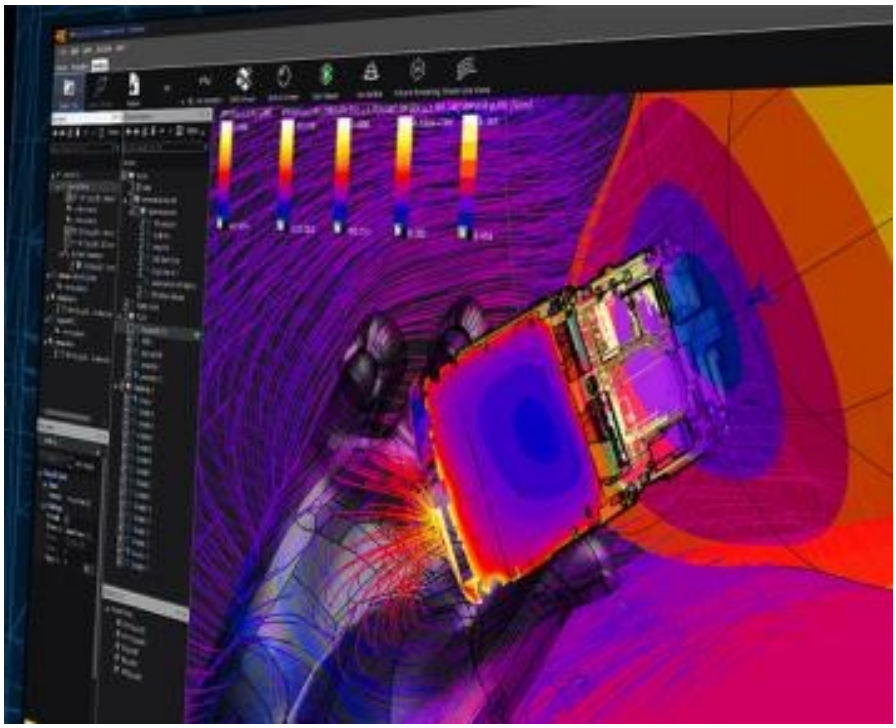
- Providing extracted average dissipated power, minimum/maximum SAR, mass and volume of every region within the 1105 sites identified in the model brain.
- Talairach landmarks, offering different mapping techniques

Applications

- design and optimization of medical treatment devices for brain conditions: DBS, TMS, TACS, ...

MBSAR

Specific SAR evaluation tool.



Product description

SAR evaluation tool for transmitters that simultaneously operate at different frequency bands.

Features

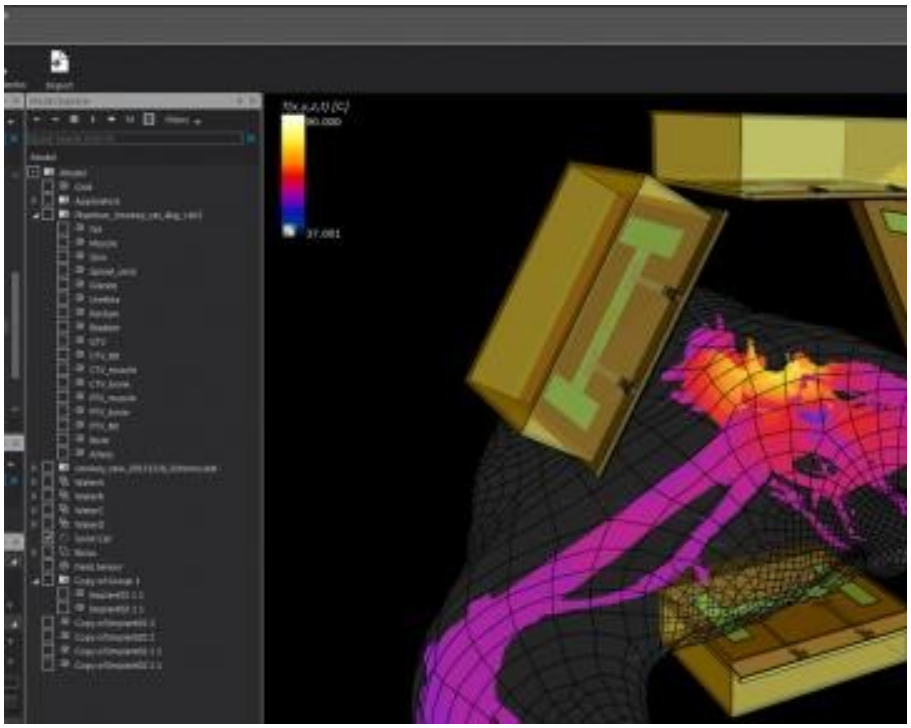
- combine the SAR pattern from simulations at different bands
- compute/visualize peak spatial SAR of the total SAR pattern

Applications

- dosimetry analysis of wireless devices with antennas operating at multiple frequencies

PHARRAY

Calculation of ideal phase/amplitude configurations for individual sources in antenna arrays, and analysis of the resulting SAR and temperature distributions.



Product description

Optimization of electromagnetic and thermal field distributions using antenna arrays to focus the energy deposition to one or multiple regions.

Features

- calculation of the ideal phases and amplitudes for the individual sources
- analysis of the resulting SAR and Temperature distribution

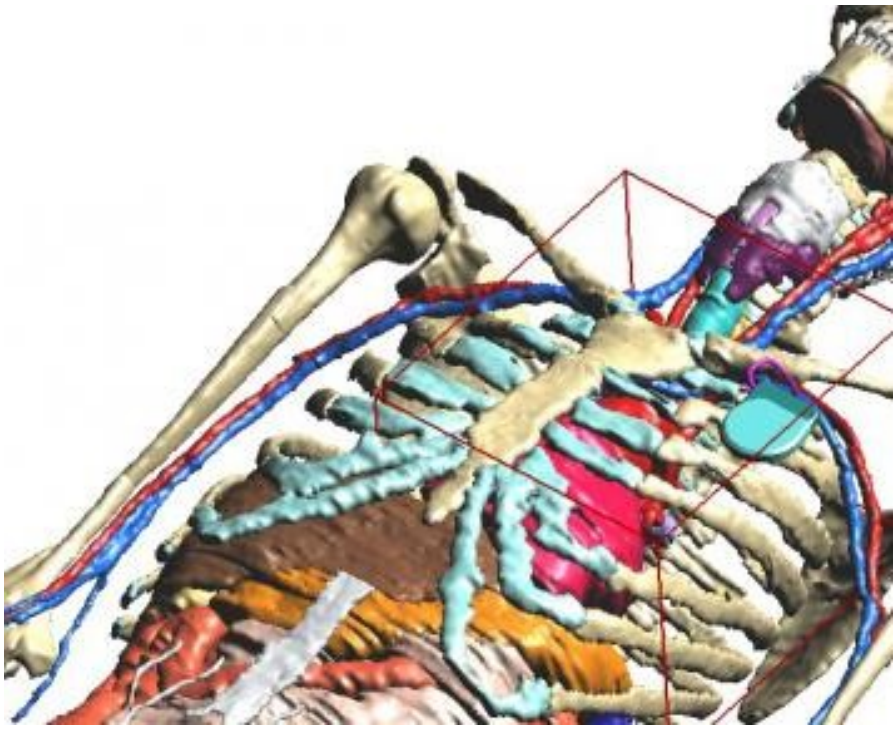
Applications

- Hyperthermia applicator
- Antenna array steering

Import Modules　导入模块

HUYGENS

Hybridization platform to import EM near-field patterns, into the generalized Huygens Source.



Product description

Hybridization platform to import EM near-field patterns, calculated with different numerical methods (FDTD, FEM, MoM), into the generalized Huygens Source.

Features

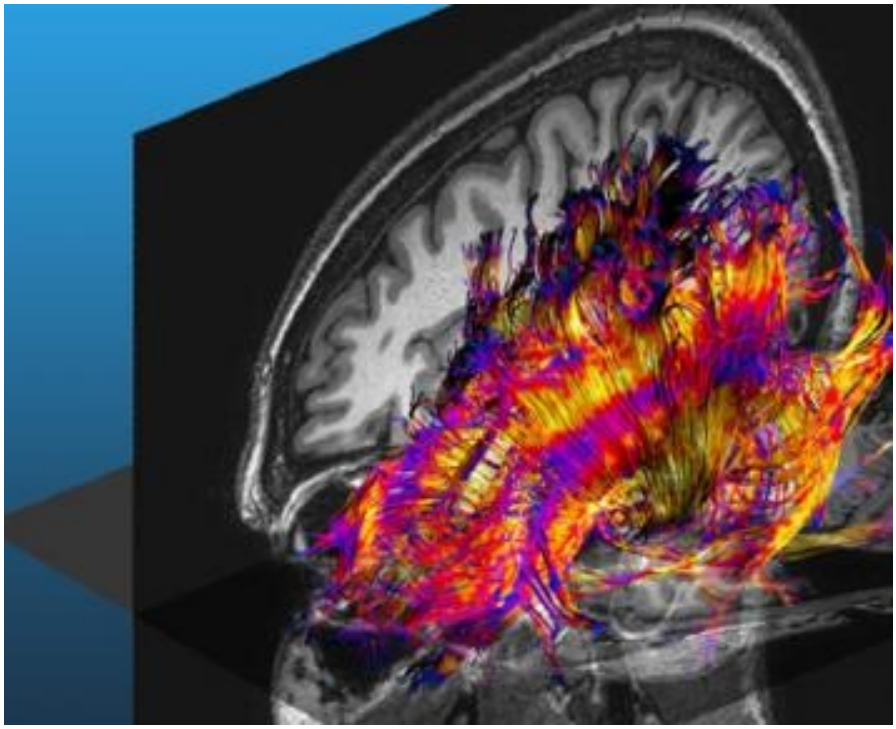
- dual-way Huygens approach
- interfaces to other MoM and FEM simulation packages (e.g., FEKO, Wipl-D)
- cascaded simulation with 3D field excitation and grid refinement

Applications

- EM exposure analysis of wireless devices
- Population studies

IMG

Import various image data for segmentation/modeling and simulation settings.



Product description

Import various image data (e.g., standard MRI and CT image formats) for segmentation/modeling and simulation settings (boundary conditions, inhomogeneous parameter distributions).

Features

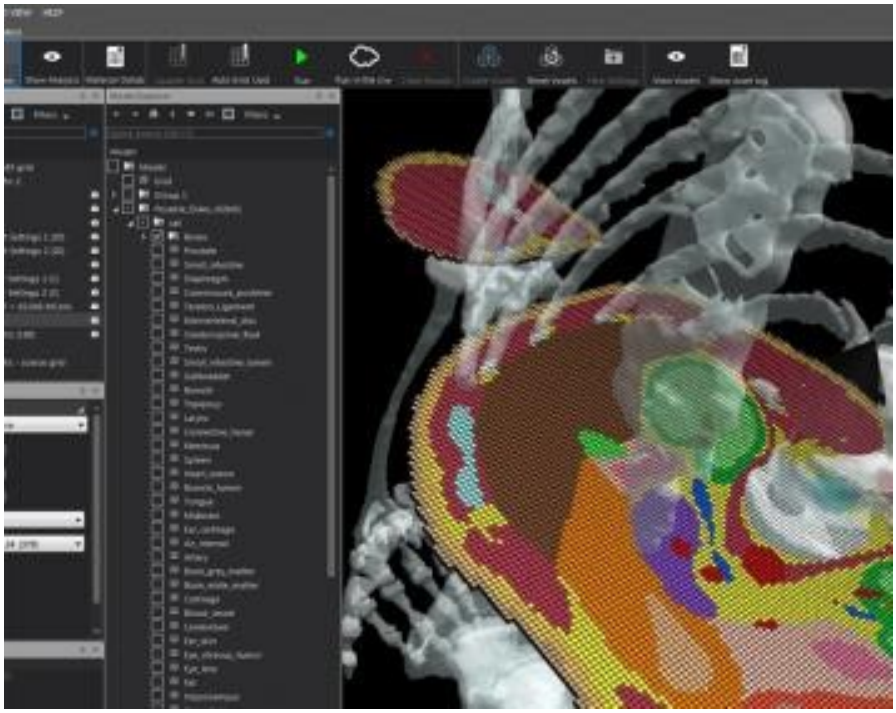
- import image data & label fields, e.g., to extract surfaces
- segmentation, registration
- assess image based properties (tissues)
- import of MRI/CT/MT based/segmented files (slices, triangles)
- img data (jpg, png, etc.)
- direct connection to iSeg
- VTI, VTP, VTU

Applications

- EM exposure analysis of (DTI)
- (developed flow profiles)

VOX

Import discretized (voxel/cloud) data and automatically convert data into segmented slices.



Product description

Import discretized (voxel/cloud) data and automatically convert data into segmented slices for use and further processing, such as surface extraction, in Sim4Life.

Features

- various voxel/cloud data formats
- .raw (volume), .bmp (slices)
- 3D voxel data from ViP
- customization options for import
- automatic detection engine
- smoothing, compound model conversion
- segmented, meshes

Applications

- any applications involving anatomical (voxel) data
- strongly inhomogeneous material distributions

Configurations 配置

System Requirements 系统要求

Software

- Microsoft Windows 7, 8, 64 bit
- Microsoft Windows Server 2008, 2012
- RedHat 5 or CentOS only for physics kernels
- Microsoft Internet Explorer 5 or higher
- Microsoft .NET Framework 3.5 Service Pack 1
- Administration rights are required for installation

Minimum Hardware

- At least 1 GB memory
- 2 GB hard disk space for the application and sample projects
- A graphics adapter with adequate OpenGL performance, capable of displaying at least 1024x768 pixels with true colors (at least 16 bits per pixel). Graphic driver that supports OpenGL v1.5 or newer.

Recomended Hardware

- 4 GB memory per core or more. When GPUs are installed, double the amount of memory in card.
- 1 TB hard disk space to include working projects and calculated results
- Power supply: at least 1kW for a 1 GPU solution
- PCIe x16

License Options 许可类型选项

Commercial Licenses 商业许可

The *Sim4Life* Commercial licenses are time limited to 1 or 3 years, renewable. During the license duration, technical support and access to the latest software versions are provided.

Academic Licenses 学术许可证

***Sim4Life* University License 大学许可证**

The *Sim4Life* University prices include the "University Discount." For time-unlimited licenses, there is no recurring yearly fee for universities. Special packages with multiple licenses (10, 20, etc.) are available upon request.

University product licenses may not be used for any commercial activity, such as:

- Commercial production design, design validation, or design assessment work.
- Commercial manufacturing engineering work
- Commercial research
- Consulting work performed by academic students, faculty, or academic account staff
- Training of commercial company employees.

***Sim4Life* Research Program 研究项目许可**

The *Sim4Life* Research Program grants the researcher non-transferable and limited number of *Sim4Life*licenses for one year. The software provides its unlimited functionality within the framework of features of the commercially available standard package for Duke and Ella computable models. The researcher shall only use *Sim4Life* for scientific research purposes at universities or academic institutes, with the commitment of publishing at least one paper per license in peer reviewed journals and/or conference proceedings. Please contact s4l-sales@zurichmedtech.com for further details.

***Sim4Life* Campus Licenses 校园许可证**

Upon request, it is possible to grant free licenses for *Sim4Life* Uni Basic Package for a limited time for teaching purposes.

License Types 许可类型

All *Sim4Life* licenses are locked to the provided USB dongle ID in Windows and Linux systems.

Node Locked Counted Licenses

The license is only available in the machine where the USB dongle is plugged. A license server must be installed in the local machine in order to count the number of allowed instances of *Sim4Life* that can be use simultaneously. Each time an instance of *Sim4Life* starts on the computer, it contacts the server and tries to acquire one license. If it succeeds, the number of available licenses on the server decreases by 1.

This type of license is only applied for Token licenses and I-DEAS CAD translator licenses.

Node Locked Uncounted Licenses

The License is only available in the machine where the USB dongle is plugged and the number of*Sim4Life* instances that can be used at the same time is unlimited.

Floating Counted Licenses

The license is shared in the network from a license server system that can be shared by a limited number of simultaneous computers in order to use *Sim4Life*. The number of licenses specified in the license file corresponds with the number of computers that simultaneously can use *Sim4Life*. The number of *Sim4Life* instances in each computer is unlimited.

Each time a new computer of the network starts *Sim4Life*, it contacts the server and tries to acquire one license. If it succeeds, the number of available licenses on the server decreases by 1. Successive license petitions from the same computer will not decrease the number of available licenses.

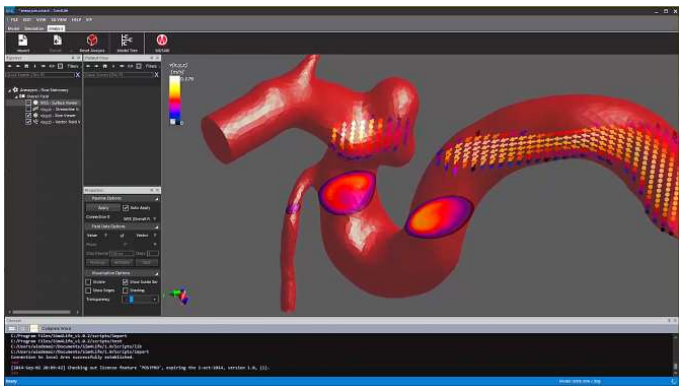
Video/Training 视频/培训

Introduction to *Sim4Leif* -SIM4LIFE VIDEO

Sim4Life combines computable human phantoms with the most powerful physics solvers and the most advanced tissue models to directly analyze biological real-world phenomena and complex technical devices in a validated biological and anatomical environment. Architected with high performance computing enabled solvers and the most intuitive GUI, Sim4Life enables accurate coupled multiphysics simulations and endless customization for accelerating R&D activities, designing and optimizing medical devices and treatments, assessing safety and efficacy, enriching personalized medicine strategies, conducting mechanistic research, reducing costs, and achieving regulatory compliance.
Please click on the movie below to watch a detailed introduction to *Sim4Life*:

Sim4Life Flow Solver-SIM4LIFE VIDEO

The *Sim4Life* fluid dynamics solver is designed to perform optimally for flow in complex geometrical structures and networks, encountered in biological systems such as the vasculature, cerebral cavities, bronchi and other fluid systems. Combined with the advanced modelling features of *Sim4Life*, including the iSeg medical image segmentation tool, and the versatile analysis and post-processing capabilities, the flow solver package provides a fully integrated end-to-end workflow. This approach offers an intuitive and efficient path from imaging data to high quality, visualized results.
Please click on the movie below to watch:



Sim4Life CAPITALIS Project Nominated for the Prestigious 2015 CTI Swiss Medtech Award

The Commission for Technology and Innovation (CTI) - one of the leading Swiss governmental technology funding institutions - has nominated the research project Sim4Life CAPITALIS for the prestigious 2015 CTI Swiss Medtech Award. The project entitled S4L CAPITALIS - In Silico Analysis and Optimization of Neurovascular and Neurological Devices and Treatments in the Head was a strong collaborative research and implementation effort by ZMT and the academic research partners IT'IS Foundation and the Translational Neural Engineering (TNE) Laboratory at EPFL and the application partner Cardiatis S.A.
The following clip provides an in-depth summary of Sim4Life and the project.: