k-Plan: From the Hospital to the Cluster and Back

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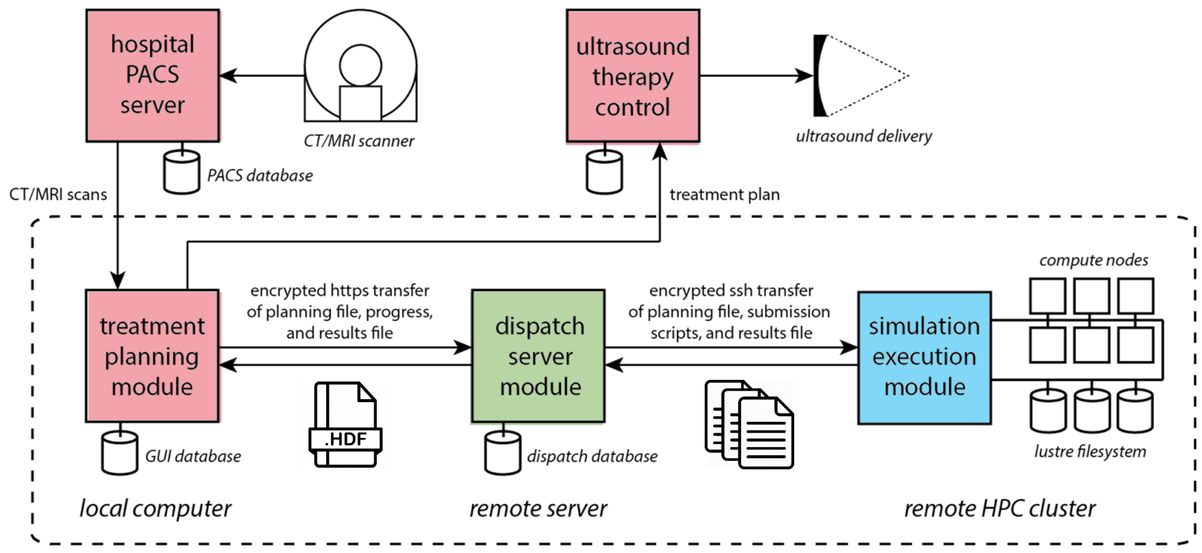
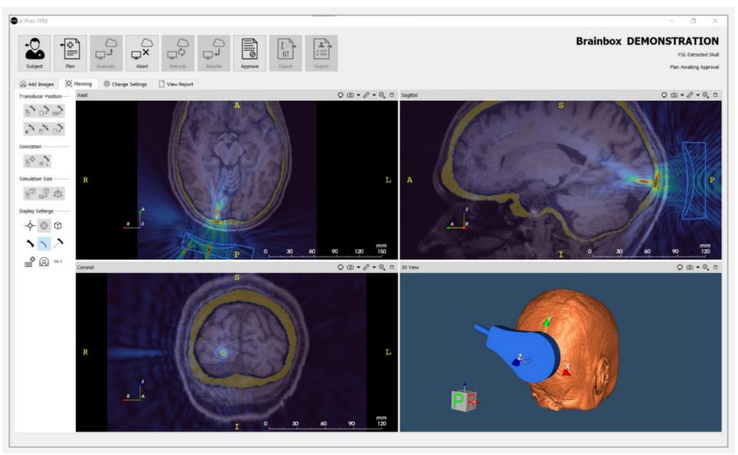
1 What Is k-Plan?

Designed for use with transcranial ultrasound stimulation (TUS) techniques, k-Plan is an **advanced modelling tool for planning TUS procedures**. k-Plan uses a streamlined and intuitive workflow that allows users to select an ultrasound device, position the device using a template or medical image, and specify the sonication parameters.

High-resolution calculations of the ultrasound field and temperature inside the skull and brain are then automatically calculated in the cloud or HPC cluster with a single click. **No knowledge of numerical modelling or high performance computing is required.**





2 Intelligent Compute Engine

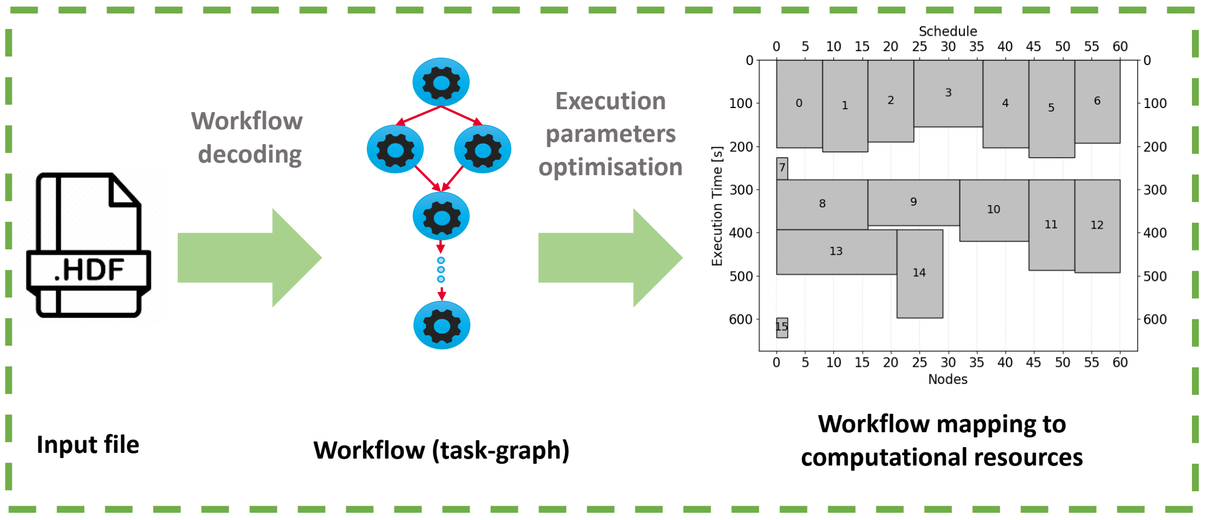
k-Plan's intelligent compute engine **automates the process of running a planning simulation** for transcranial ultrasound procedures. It automatically maps from CT skull images to material properties, generates an accurate model of the transducer based on geometric and calibration information, and then sets appropriate numerical and computational parameters. Simulation outputs are automatically processed to display the ultrasound field and temperature inside the brain, and to calculate exposure parameters.

3 State-of-the-Art Simulation Tool

Behind the scenes, k-Plan runs simulations using **k-Wave**, a state-of-the-art simulation tool that is widely used across academia and industry to study **acoustic wave propagation**. It uses an **experimentally-validated full-wave acoustic model** to calculate how ultrasound waves travel from a transducer through the skull and into the brain. This is coupled with **a model of heat diffusion** and **perfusion** to calculate temperature rise and thermal dose.

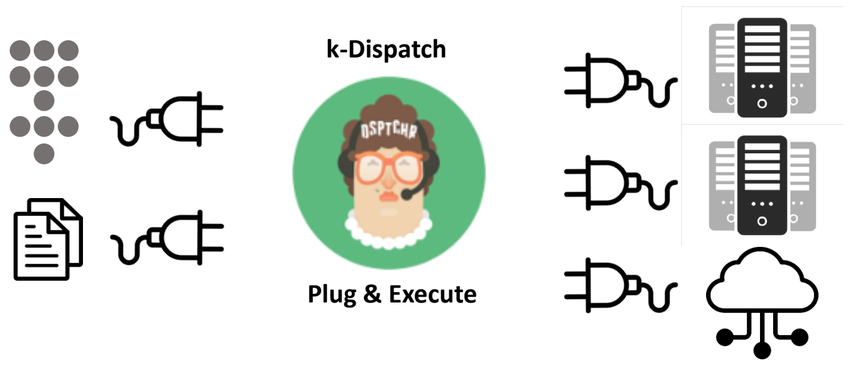
4 Cloud-based Planning Simulations

k-Plan allows access to high-performance computing resources in the cloud to run high-resolution planning simulations with a single click. The simple installation procedure and intuitive workflow mean users can be running simulations within minutes, with no additional resources or accounts required. k-Plan's automated dispatch server (k-Dispatch) **optimises the computing resources** needed for every simulation, **minimising the time between planning and results**. The status of running simulations is automatically refreshed and displayed in the plan browser.



5 Workflow Integration

k-Plan integrates into standard **neurostimulation workflows**, including importing and exporting transducer positions for use with **neuronavigation systems** and **exporting plan reports**.



6 Advanced Web Portal

k-Plan's web portal provides a **complete snapshot of your account**, including current cloud computing **allocations**, and **usage history**. Self-service options allow administrative users to add or remove accounts associated with the same software license and modify user privileges.

7 k-Dispatch's Plug & Execute Design

k-Dispatch implements easily extendable design **to add new computational workflows** (a task graph defining task types and dependencies), **support new computing facilities** and **decode new input data**.

8 Conclusions

k-Plan is a complex tool covering **medical modelling tool** and k-Dispatch, a **tool for offloading and managing remote executions** together with **accounting, reporting, and fault tolerance**. The fundamental goal of k-Plan is bringing HPC and cloud technologies to medical environment in a user-friendly way, allow putting stress on either minimal execution time or cost and develop scalable software.

9 Current and Future Work

Next steps in the development are to

(1) **tune codes** to better utilize remote resources,
(2) **include logs** to monitor computation progress,
(3) **include advanced machine learning techniques** to improve execution planning using the performance database including tens of thousands of records,
(4) **get** information about current remote facility **utilization**.

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