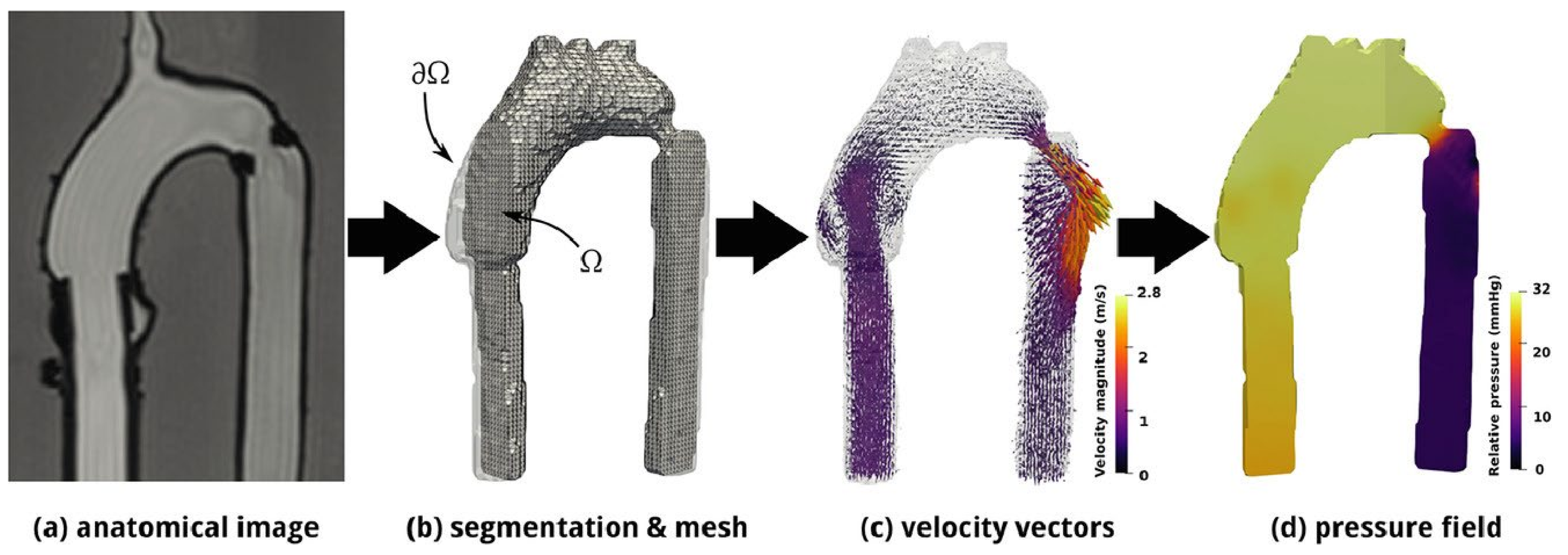
# Mathematics for Medical Imaging

4TU+.AMI **unites the applied mathematics departments** of TUDelft, TU/e, RUG, UT, and WUR. Working alongside clinical partners, our **mathematicians use fundamental principles** to develop novel, technologically sound methods for medical imaging and image analysis. We ensure that these tools are both reliable and robust, delivering precise, key information for **diagnosis**, **prognosis**, and **treatment planning** across a wide range of diseases.

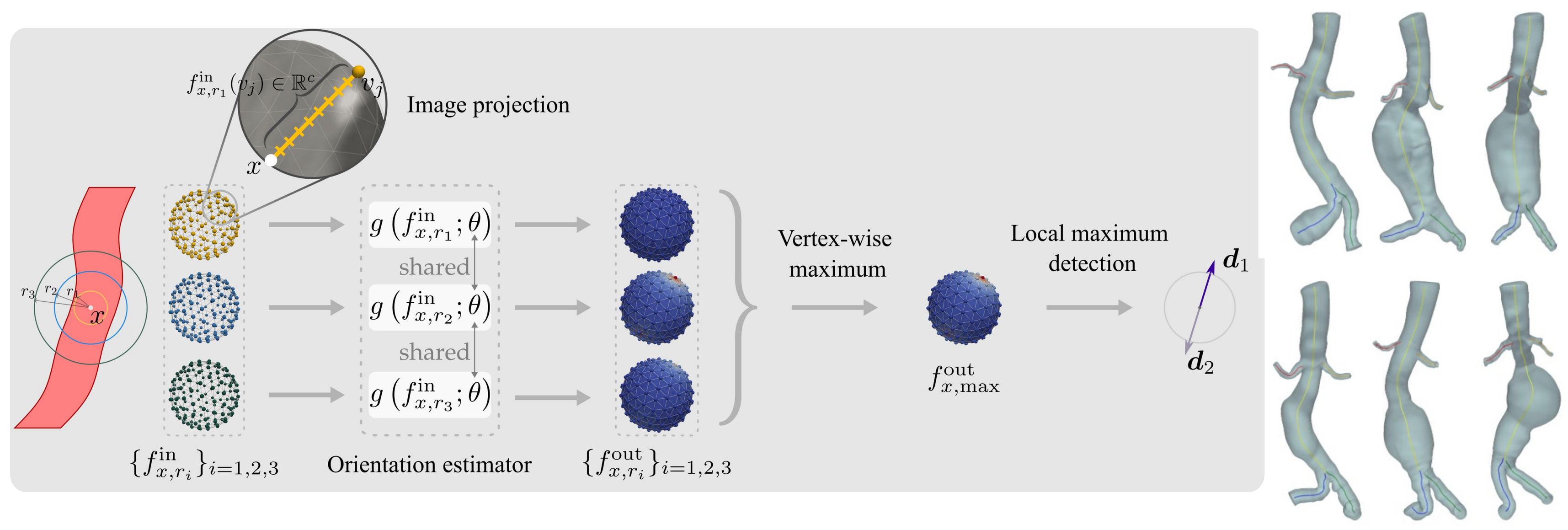
## Measuring Pressure in 4D Flow MRI




Accurately measuring blood pressure drops across narrowed vessels currently requires an invasive catheter procedure. To solve this problem, the incompressible Navier-Stokes equations can be applied to convert non-invasive 4D flow MRI measurements of blood velocity directly into relative pressure fields through **direct estimation methods**. The development and validation of these mathematical models bridges the gap between imaging technology and fluid dynamics. Ultimately, this allows evaluation of cardiovascular disease severity without the need for invasive catheterization, for example in aortic coarctation.


**Dr. Cristóbal Bertoglio, RUG**


## Personalized Artery Modeling




High-quality patient-specific 3D geometries of blood vessels can be used to diagnose disease or plan treatments. Commonly used artificial intelligence (AI) models fail when faced with blood vessels smaller or more curved than those they were trained on. By exploiting data symmetries, **geometric deep learning** models learn to segment blood vessels of varying sizes and locations. This enables generalization to entirely new vascular structures without requiring new training datasets. This is used to develop highly personalized 3D models of the patient's vasculature for patients with aneurysms or coronary artery disease.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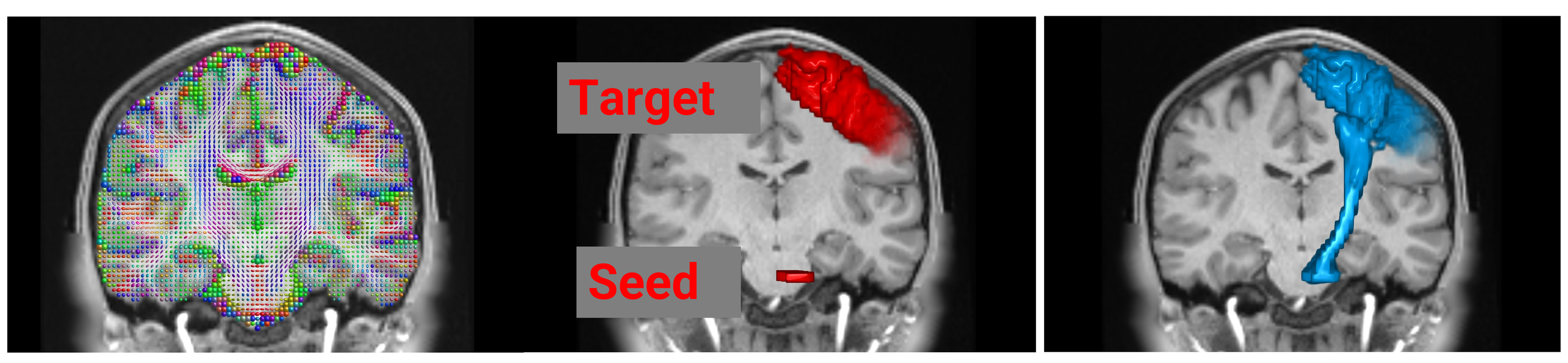
## Tractography in Diffusion Tensor Imaging




**DTI Tensor Field** **OT-Based Tractography**

Tractography, accurately mapping complex neural pathways in the brain from non-invasive Diffusion Tensor Imaging (DTI), is a challenging inverse problem. Solving this problem typically requires computationally expensive methods that calculate thousands of individual curve trajectories. Alternatively, this problem can be solved by applying **optimal transport** (OT) on data-driven MRI-derived metric tensor fields derived from MRI. These mathematical models enable rapid, accurate visualization of critical brain connections, such as the corticospinal tract shown here.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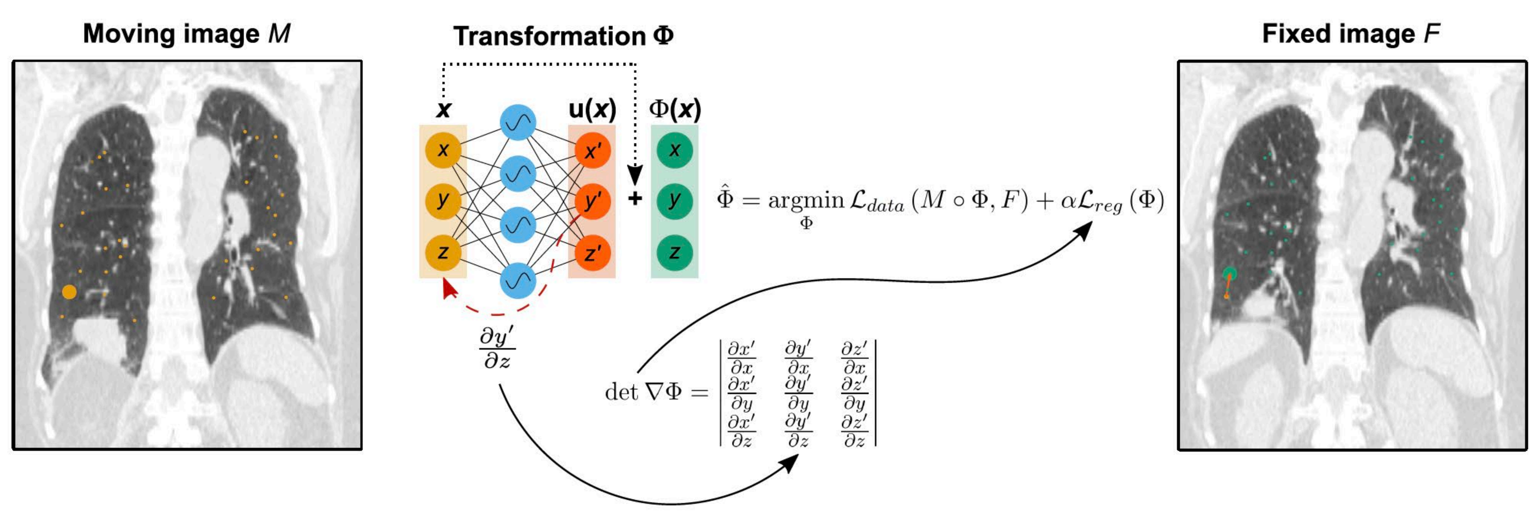
## Neural Representations for Image Registration




Precise alignment of 3D medical images, such as tracking lung motion between breathing phases, requires a model for deformation that is flexible, accurate and robust to unphysical tissue folding. By parameterizing the deformation as a neural network with periodic activation functions, a **continuous deformation field** can be obtained to solve this problem. This mathematical model allows accurate mapping of physiological motion at any resolution without requiring massive training datasets, with applications across scales ranging from histopathology to MRI registration.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