



Radboud University



Custom helmet design for OPM-MEG data

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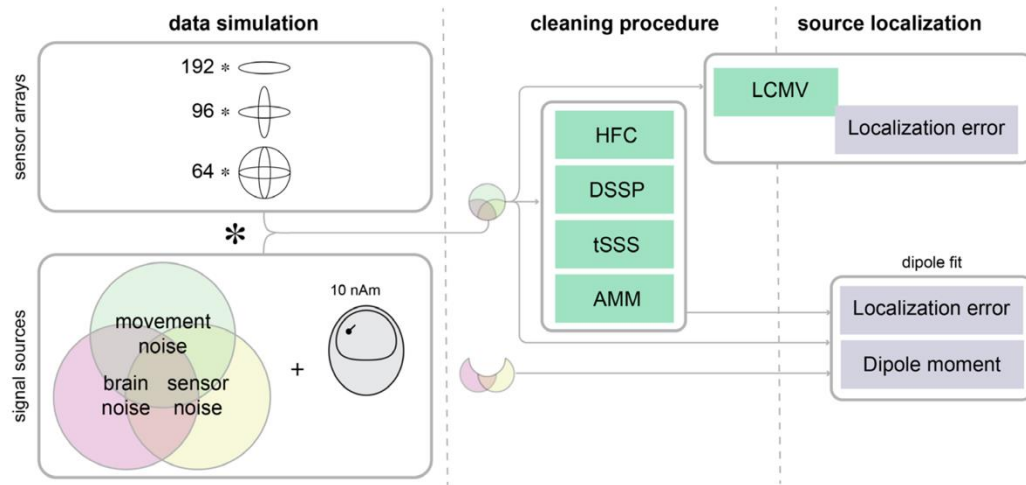
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Karolinska
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What is the optimal OPM configuration?



Imaging
Neuroscience

an open access journal

Research Article



Optimal configuration of on-scalp OPMs with fixed channel counts

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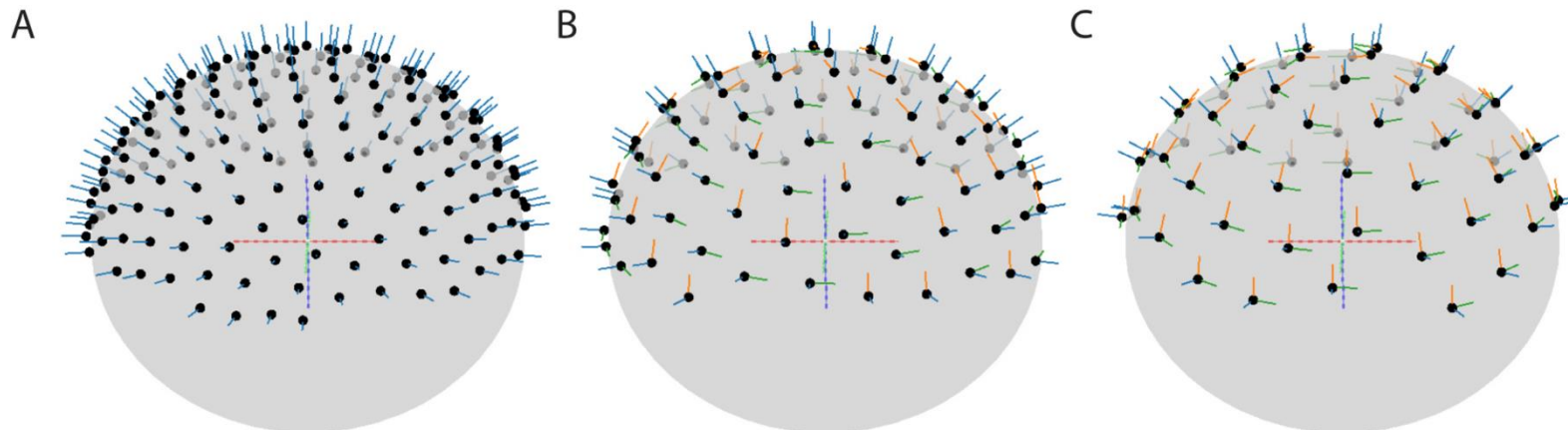
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Why do we need custom helmets?

We want the OPM sensors to be close to the head:

- Individualized custom helmets provide the best fit

- Infant/children helmets need to be smaller

We want to use OPMs for different experimental designs:

- Lightweight helmet when moving or walking

- Rigid and sturdy helmet with seated head-fixed participants

We want to adapt helmets to specific use cases:

- MEG combined with transcranial ultrasound stimulation (TUS)

- MEG combined with VR goggles

We don't have that many OPMs and want to use them optimally.



Why don't we use EEG-like caps?

Pros:

EEG caps are flexible and accommodate different head sizes.
EEG-like caps are also used for placing fNIRS optodes.



SIZES L M S

Cons:

You need to determine the individual OPM sensor positions *and orientations*.
The cables of many OPM sensors are relatively heavy and thick.
When pulling the cables (e.g. while moving) the orientation of the sensor relative to the cap can change.
The stretchiness is not that large, you still need to switch the OPMs between caps.



What is involved?

The OPM sensors: how large, how many, in which orientation?



FieldLine



QuSpin/Cerca



MAG4Health

Also:

Hamamatsu
QuanMag
Marvel

...

The design of the helmet

The fabrication of the helmet

3D printing methods

Different methods to deposit material

Material Extrusion (**FDM** / FFF)

Vat Polymerization (**SLA** / DLP / LCD)

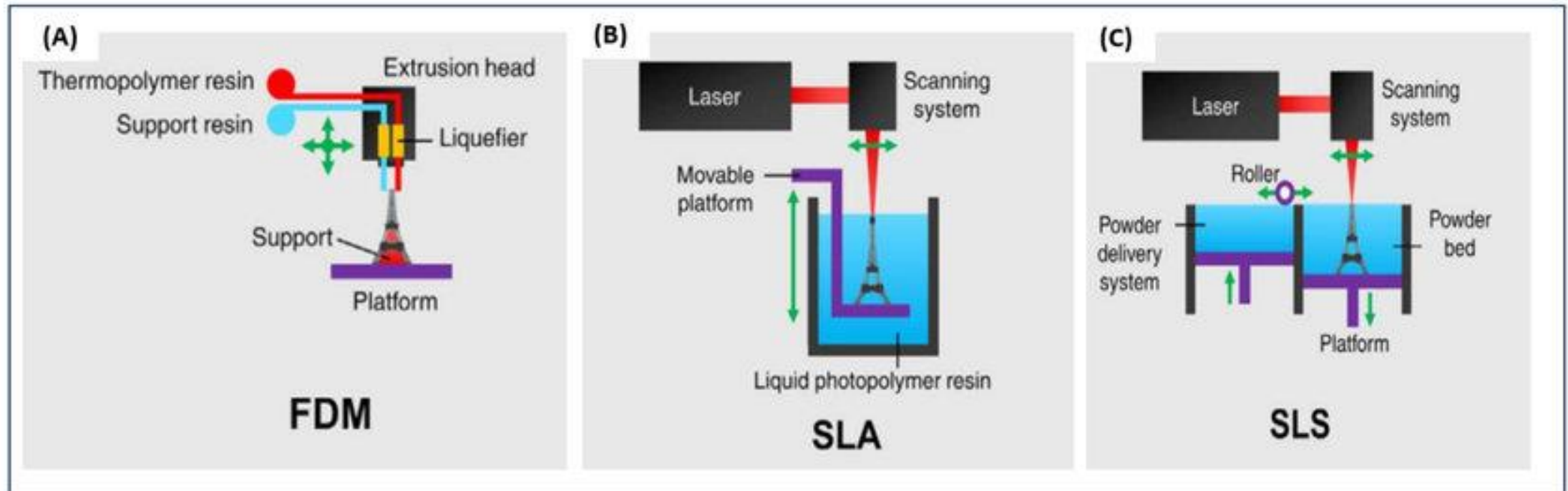
Powder Bed Fusion (**SLS** / MJF / DMLS)



FDM

SLA

SLS



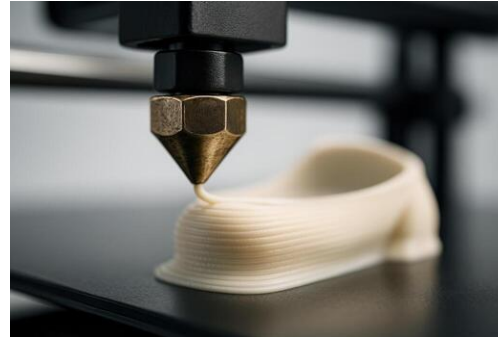
3D printing - Fused Deposition Modeling (FDM)

Spool of plastic filament (e.g. PLA) that melts at relatively low temperatures

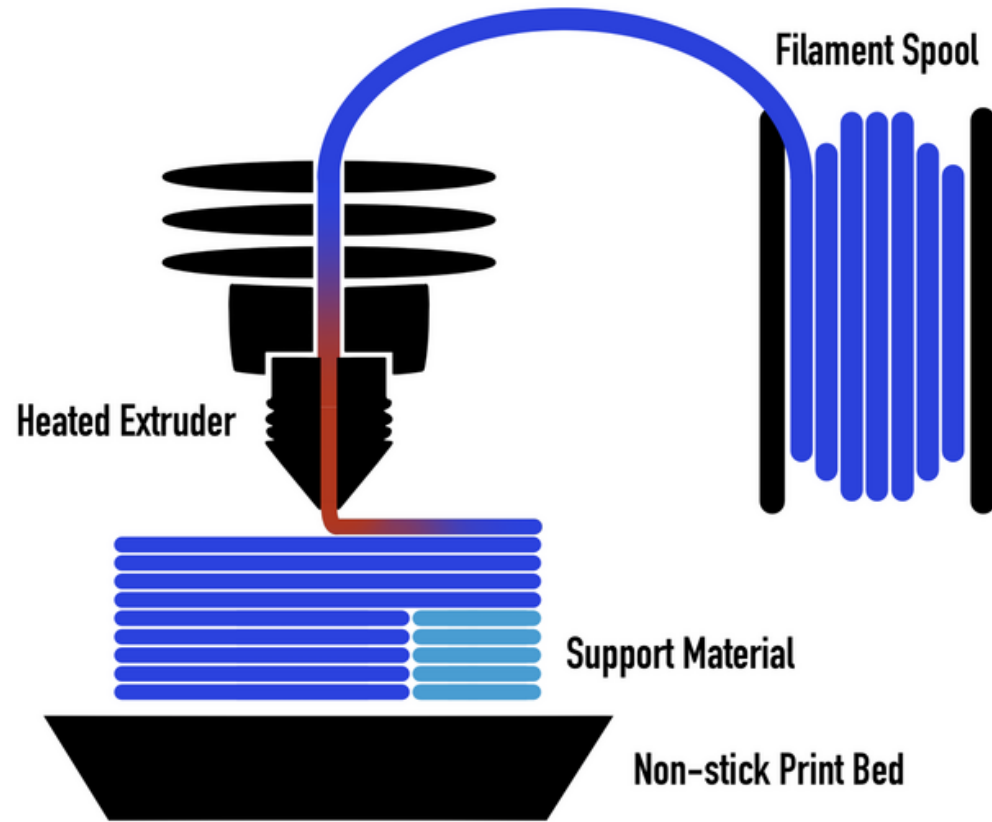
Print head or “extruder” with heated nozzle, typically 0.4 mm

Print bed, often heated and with a specific adhesive coating

The printing head and/or the print bed move very precisely according to the gcode instructions, while material is extruded



3D printing - Fused Deposition Modeling (FDM)



3D printing - Fused Deposition Modeling (FDM)

Things to consider when buying an FDM 3D-printer

- What is the accuracy?

- What materials can it work with?

- What is the print volume?

- How is calibration handled?

FDM printers cost between 300 euro for an affordable one, 1000 euro for a very decent one, and >10k for industrial ones.

FDM printer material costs 20-50 euro per kg. So one helmet is ~20 euro in material.

The skills to operate a 3D printer (and the 3D design software) and the time it takes makes it expensive.

Other printers (SLA, SLS) can be more expensive and are more difficult to use.

3D printing companies can print for you, but won't do the design.

Material and fabrication considerations

Precision

Strength

Smoothness

Temperature resistance

Biocompatibility

Ability to clean surfaces

3D design (prior to printing)

3D design is done with specialized software like Fusion and Solidworks. Both are commercial, but have free educational licenses.

Fusion and Solidworks are good at 3D models, not at data. Hence in the design process we combine them with MATLAB.

STL files are most commonly used format to exchange (closed) surface descriptions between 3D design software packages.

Following the 3D design we need “slicer” software that translates the design into instructions for the specific machine. This results in gcode files.

Helmet design demonstration

https://www.fieldtriptoolbox.org/tutorial/sensor/opm_helmet_design/