# Management of head motion during MEG recordings with Flying Triangulation


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We use the Flying-Triangulation principle for the motion tracking of a h uman head, while recording MEG (magnetoencephalography) data. Due to inevitable head motion during a recording (~30 min), tracking is necessary to maintain the correspondence between brain and sensor, with high accuracy. A crucial constraint is here the extreme sensitivity against magnetic perturbations.


## 1 Introduction

An MEG (magnetoencephalography) data recording typically takes about 30 minutes. During the recording, head motion is generally inevitable. Maintaining a high-accuracy correspondence between brain and MEG sensor requires head motion tracking. A crucial constraint of this tracking task is that MEG recordings are extremely sensitive against magnetic perturbations.

Commonly, one of two tracking methods is employed: Either 2D images are taken or some coils attached to the patient's head are localized, both before and after the MEG measurement and then compared. The problem of such "offline" methods is that the motion during the MEG measurement is not captured. Although coils can also be used "online", this method still suffers from artefacts.

We propose to use the "Flying Triangulation" (FlyTri) principle [1, 2] for the head motion tracking while recording MEG data. The property of FlyTri to capture 3D data in real time with on-board alignment allows for a continuous motion tracking. However, available FlyTri sensors cannot be used interference-free inside an MEG environment. Therefore, we developed a FlyTri sensor which is suitable for this task: It enables a continuous tracking during the MEG recording and satisfies the given constraints. In this paper, the novel sensor is described and measurement results given.

## 2 Flying Triangulation

Flying Triangulation (FlyTri) is an optical 3D measurement principle [1, 2] which allows for a motion-robust surface acquisition, even of complex objects. For usual applications, the resulting dense 3D model is of main interest while the relative sensor-object motion is secondary. For the task of motion tracking, however, the aspect changes: We are not longer interested in acquiring a dense 3D model. Now the relative motion between sensor and object becomes our main focus. Hence, the work flow of FlyTri is now as follows (Fig. 1): From the stream of raw 2D camera images, 3D views (sampling lines) are generated and static parts (of MEG helmet-shaped dewar) removed which do not reflect the head motion. The resulting 3D data

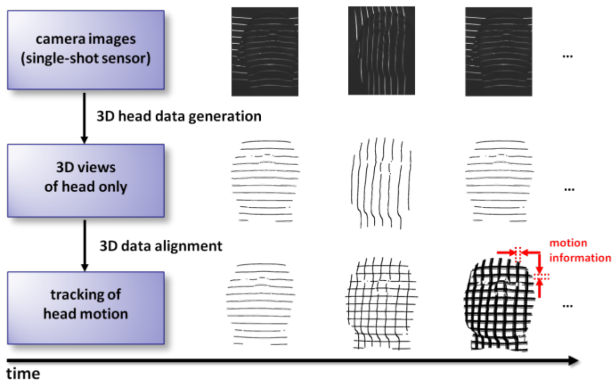


***Fig. 1*** *Work flow of FlyTri for motion tracking task.*

can then be used to retrieve the motion information (see also Fig. 2). This information can be processed to correct the acquired MEG data for head motion.

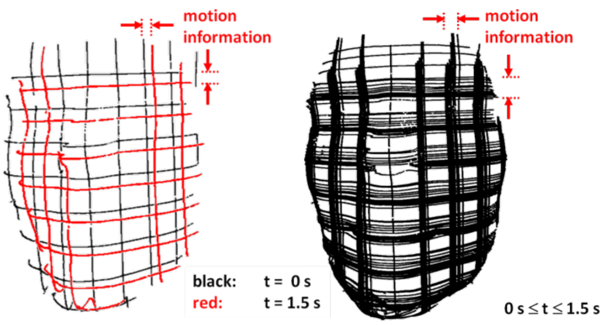


***Fig. 2*** *Retrieval of motion information from aligned consecutive 3D sampling lines of a person's head. Left: Motion information obtained at two time points. Right: Alignment of series of 3D sampling lines yields continuous motion information over the entire acquisition period.*


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## 3 Motion tracking inside MEG environment

Crucial for this task is that the head motion is continuously tracked during an MEG measurement. As an MEG acquires a brain's magnetic field in the order of some femtotesla, it needs to be positioned inside a magnetically shielded room (MSR, Fig. 3), together with the motion tracking device.

***Fig. 3*** *MEG inside its magnetically shielded room (MSR).*

As available FlyTri sensors interfere with MEG data, we built a sensor suitable for this task: The resulting "MEGfly" sensor consists of a shielded camera and fiber-coupled lasers with all sources located outside the MSR (Fig. 4). The volume of measurement is $200 \times 150 \times 180\ mm^3$ and the working distance is 1000 mm. The camera runs with 15-30 fps. The design of the sensor allows for an interference-free online motion tracking.

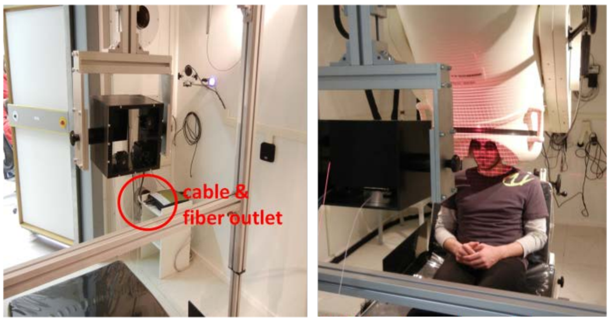


***Fig. 4*** *MEGfly sensor inside MSR, in action.*

## 4 Results

A person was seated in the MSR under the MEG helmet-shaped dewar and its head motion tracked for three seconds. The head data acquisition steps are depicted in Fig. 5. For safety reasons, the person used protective eyewear. The corrected 3D views were then aligned to each other employing standard FlyTri software.

The displacement information of the resulting 3D model, given by the registration parameters, can then be applied to correct MEG data for head motion.

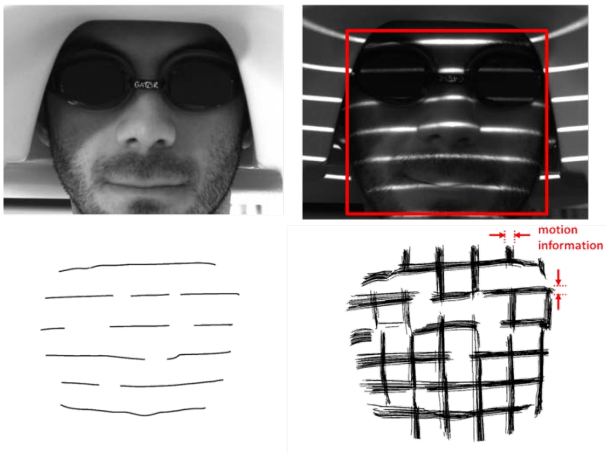


***Fig. 5*** *Head data acquisition for motion management. Top left: Camera image of person seated below an MEG dewar. Top right: Camera image captured by MEGfly sensor with region of interest (rectangle). Bottom left: 3D view of person's head only. Bottom right: Aligned 3D result (t = 3 s). The registration information can be applied to correct MEG data for head motion.*

## 5 Summary and outlook

We presented a novel method for head motion management inside the MEG environment. The resulting MEGfly sensor based on our recently developed Flying Triangulation principle meets the key challenges of this task: continuous and contactless head surface data acquisition not interfering with MEG data. The ease of use, motion robustness, and scalability of FlyTri sensors opens a wide range of applications, such as co-registration of multimodal medical data [3] and respiration management in radiation therapy [4].

## Acknowledgement

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