Summary of coil system progress

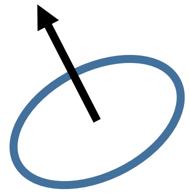
Zhetuo, 08/28/2018

Some background:

- The frame generates a uniform magnetic field (more uniform at the center) , which leads to consistent and accurate measurement of the coil orientation

- The coil system alone can only measure the orientation, which can only give us eye rotation in the head. We need translation motion measurement to reconstruct line of sight and gaze point on the screen in a head free experiment.

- Each coil returns a vector, which is its orientation in the room coordinate.

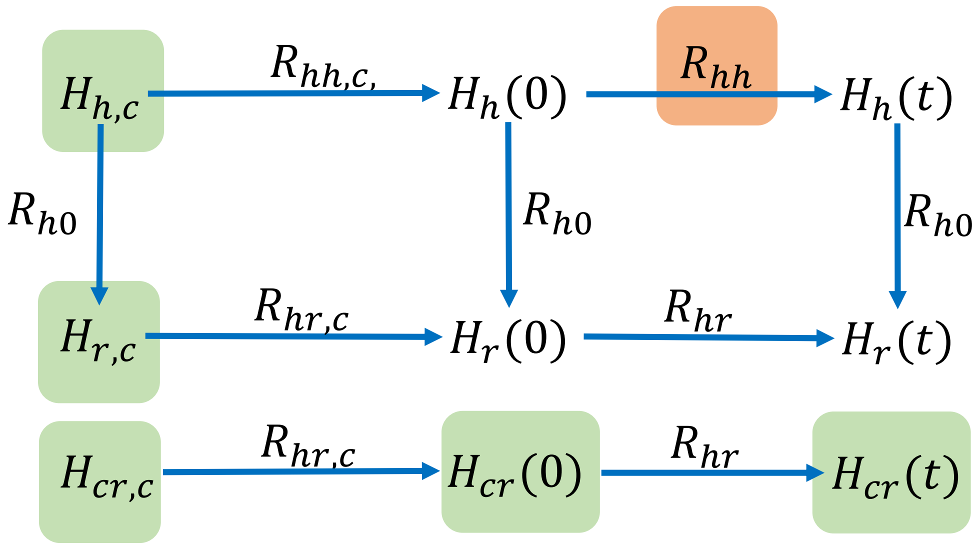


- Each coil can measure pan and tilt angle, but not the roll

- Two head coils gives a head frame

- One eye coil

- Why do we need calibration



	Head in head	Head in room	Head coil in room
Calibration	$H_{h,c}$	$H_{r,c}$	$H_{cr,c}$
Origin of the screen	$H_h(0)$	$H_r(0)$	$H_{cr}(0)$
In experiment	$H_h(t)$	$H_r(t)$	$H_{cr}(t)$

Calibration provides the coordinate transformation from room reference to head reference

$$R_{h0} = H_{r,c} {H_{h,c}}^{-1} = H_{r,c}$$

Head coil measurements give the rotation matrix in the room reference

$$R_{hr} = H_{cr}(t)(H_{cr}(0))^{-1}$$

$$R_h = R_{h0}^{-1} R_{hr} R_{h0}$$

$$\boldsymbol{e}_{\boldsymbol{r},\boldsymbol{c}} \xrightarrow{R_{er}} \boldsymbol{e}_{\boldsymbol{r}}(t)$$

$$\boldsymbol{e}_{\boldsymbol{cr},\boldsymbol{c}} \xrightarrow{R_{er}} \boldsymbol{e}_{\boldsymbol{cr}}(t)$$

$$\boldsymbol{e}_{\boldsymbol{r},\boldsymbol{c}} \xrightarrow{R_{er,c}} \boldsymbol{e}_{\boldsymbol{r}}(0)$$

$$\boldsymbol{e}_{\boldsymbol{cr},\boldsymbol{c}} \xrightarrow{R_{er,c}} \boldsymbol{e}_{\boldsymbol{cr}}(0)$$

	Eye in head	Eye in room	Eye coil in room
Calibration		$\boldsymbol{e}_{\boldsymbol{r},\boldsymbol{c}}$	$\boldsymbol{e}_{\boldsymbol{cr},\boldsymbol{c}}$
Origin of the screen	$\boldsymbol{e}_{\boldsymbol{h0}}$	$\boldsymbol{e}_{\boldsymbol{r}}(0)$	$\boldsymbol{e}_{\boldsymbol{cr}}(0)$
In experiment	$\boldsymbol{e}_{\boldsymbol{h}}$	$\boldsymbol{e}_{\boldsymbol{r}}(t)$	$\boldsymbol{e}_{\boldsymbol{cr}}(t)$

$$\boldsymbol{e}_{\boldsymbol{r}}(\mathrm{t}) = R_{er}\boldsymbol{e}_{\boldsymbol{r},\boldsymbol{c}}$$

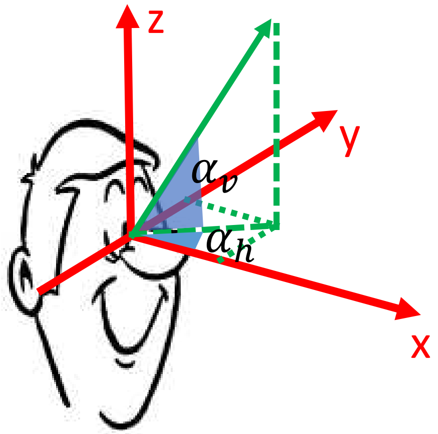
where R_{er} can be derived from $\boldsymbol{e}_{\boldsymbol{cr}}(\mathrm{t}) = R_{er}\,\boldsymbol{e}_{\boldsymbol{cr},\boldsymbol{c}}$

$$\boldsymbol{e}_{\boldsymbol{h}} = H_r^T\boldsymbol{e}_{\boldsymbol{r}}$$

$$\alpha_h = -\arctan\left(\frac{e_{hy}}{e_{hx}}\right)$$

$$\alpha_v = \arctan\left(\frac{e_{hz}}{\sqrt{e_{hx}^2 + e_{hy}^2}}\right)$$

$$\alpha_h = \alpha_h - \alpha_{h0}$$
$$\alpha_v = \alpha_v - \alpha_{v0}$$

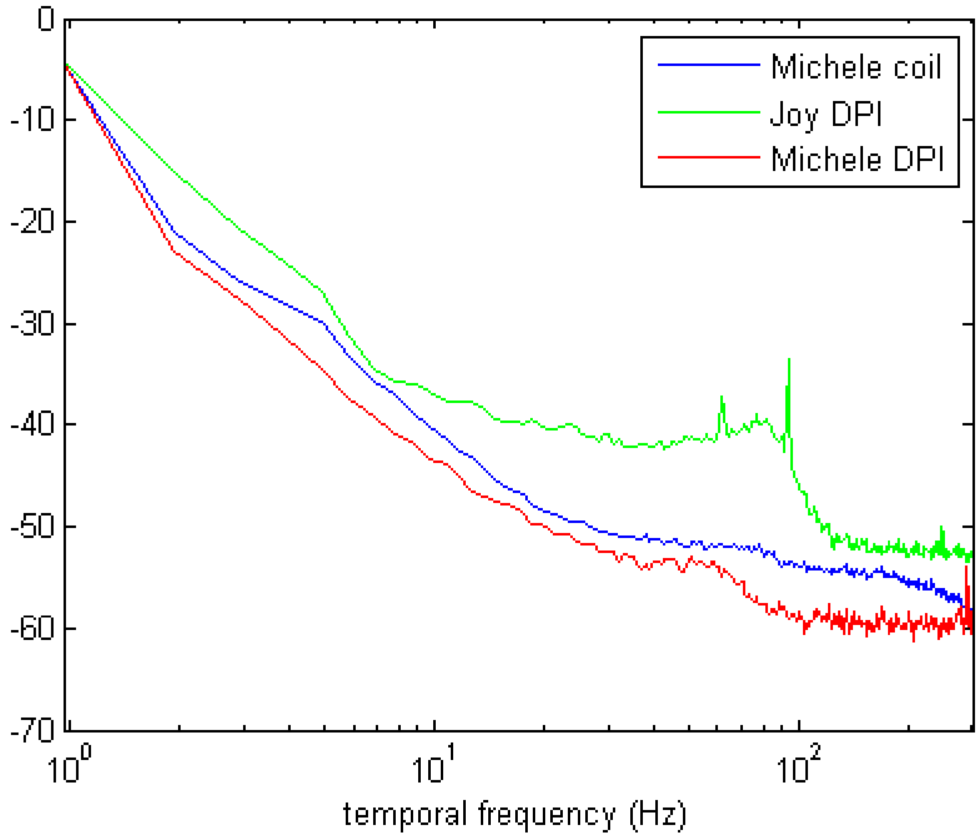


Calibration:

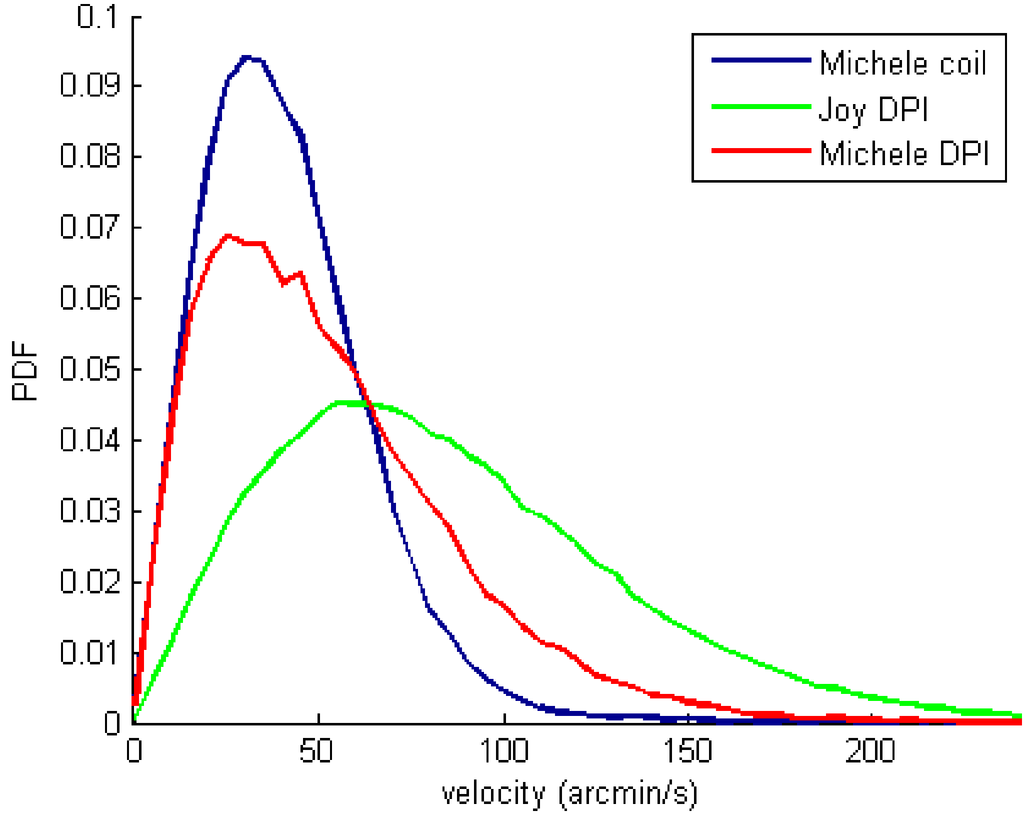
- Calibrate the coils
- Setup the head rest
- Use semi-transparent sheet to adjust the position of the screen and the height of the head rest
- Change to mirror
- Attach the calibration coil to the head rest (direction matters)
- Put on the head coil
- Insert the eye coil
- Look at left eye in the mirror (5 sec, one trial)
- Look at right eye in the mirror (5 sec, one trial)
- Remove the mirror or the entire head rest
- Start the experiment

A comparison of drift data between coil system and DPI data:

Power spectrum of eye movement

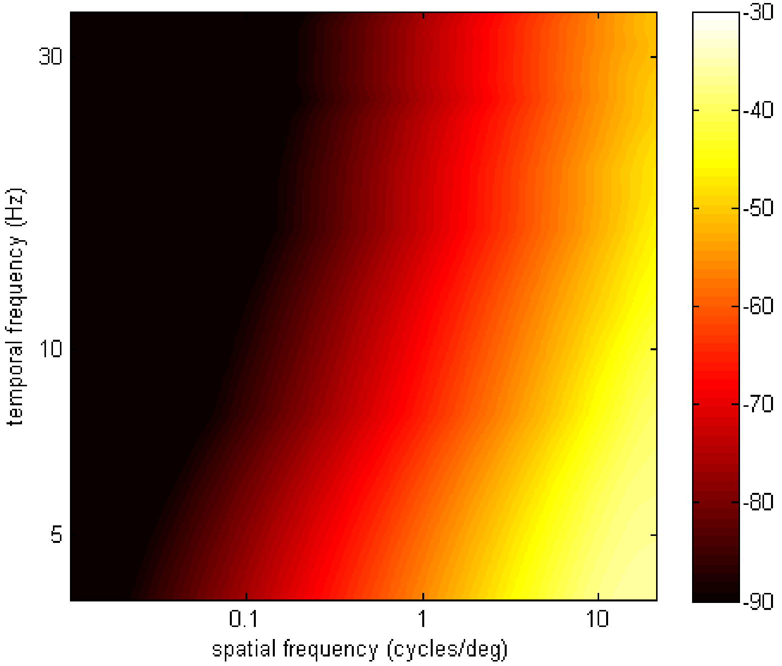


Distribution of velocity

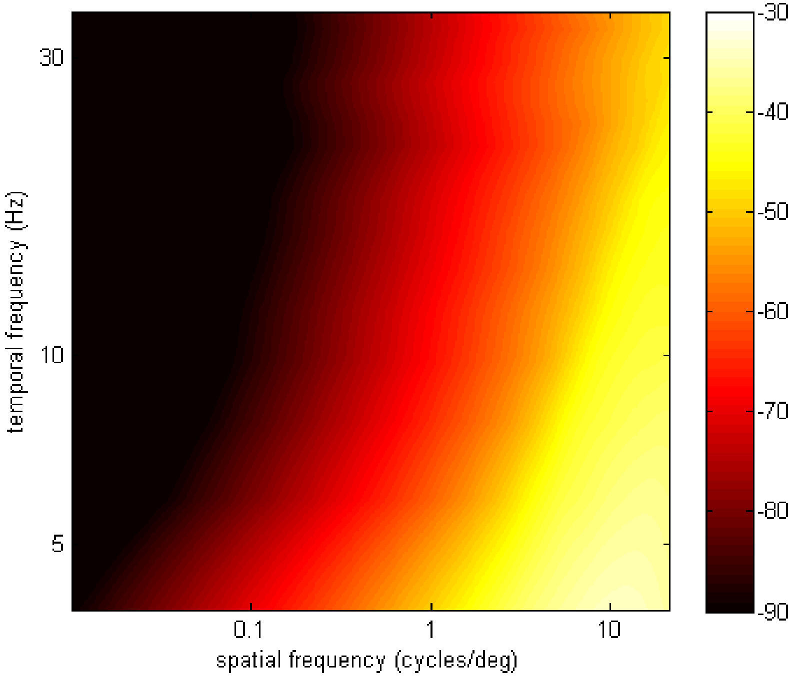


A comparison of drift data between coil system and DPI data:

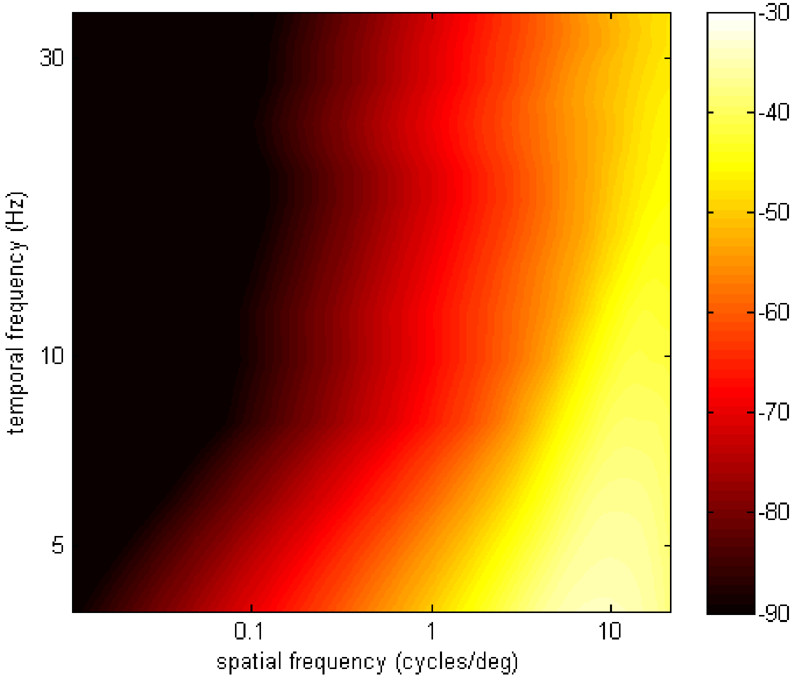
Michele coil



Michele DPI

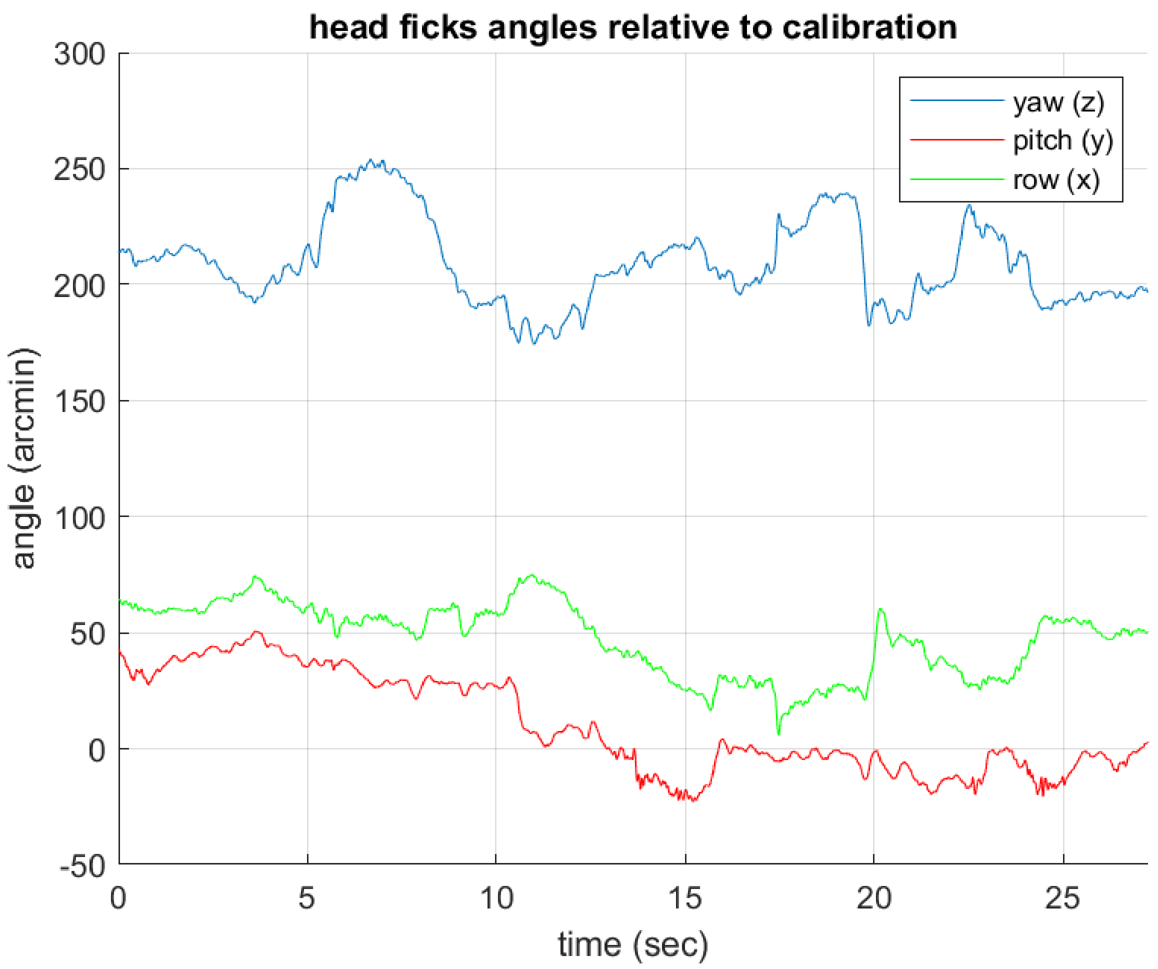


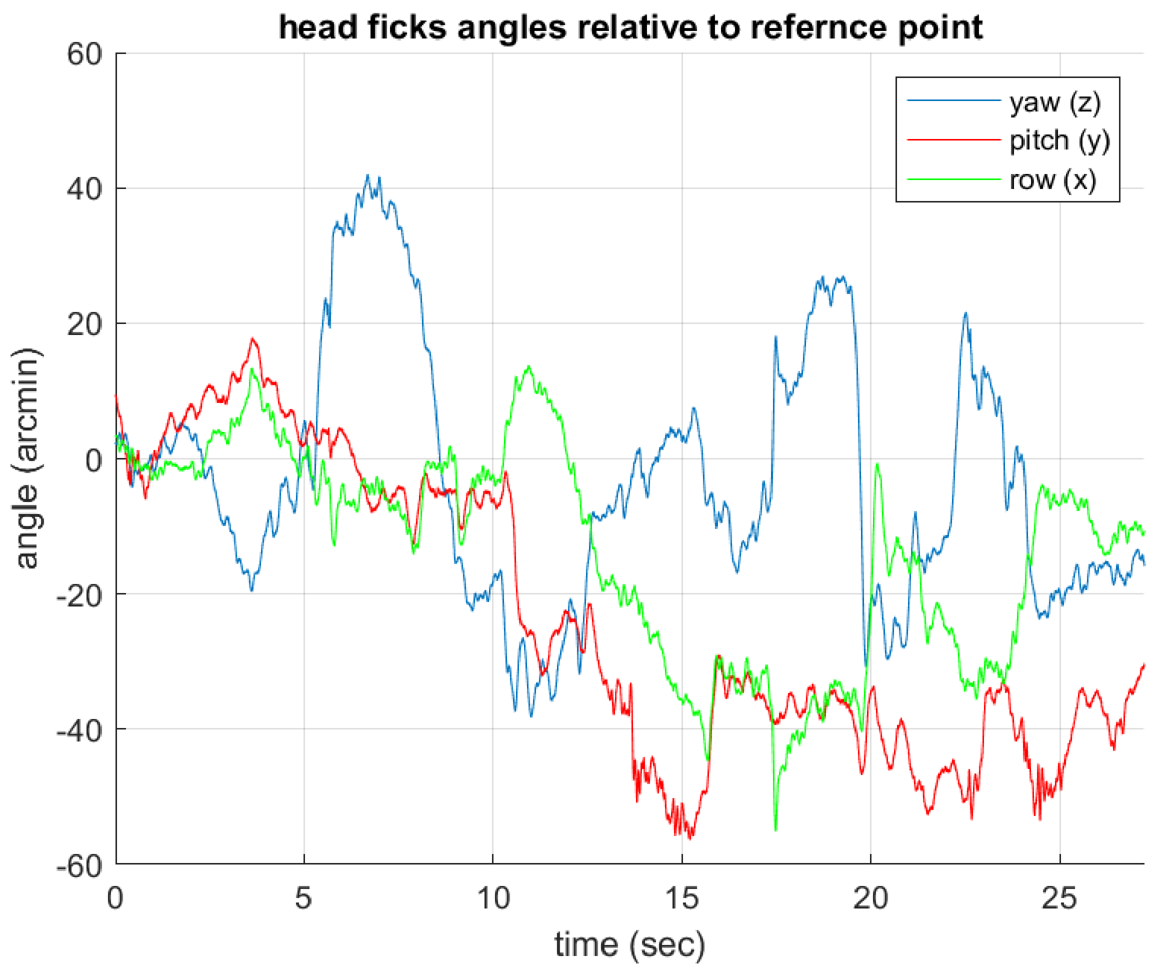
Joy DPI



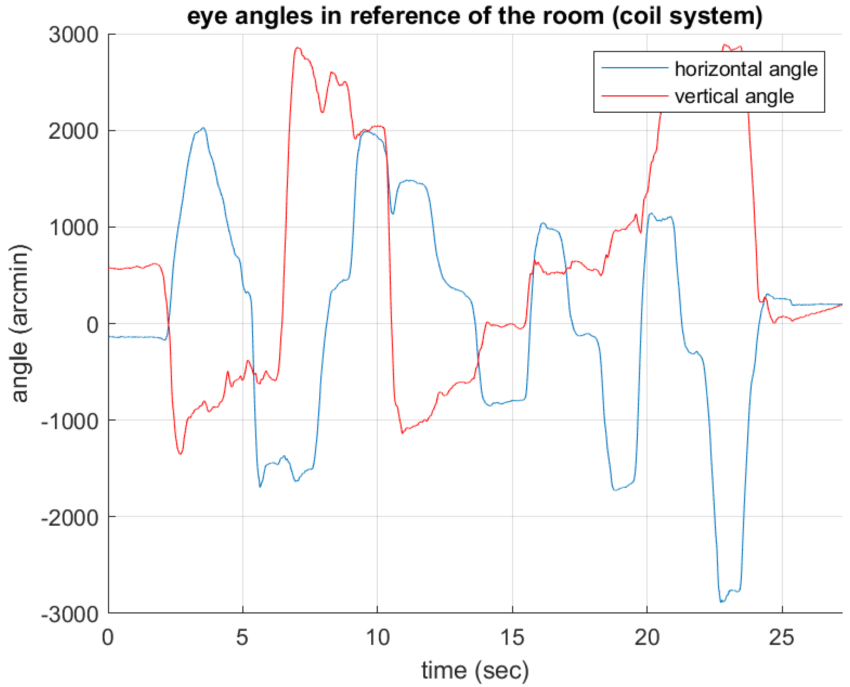
Dry run on 08/14/2018

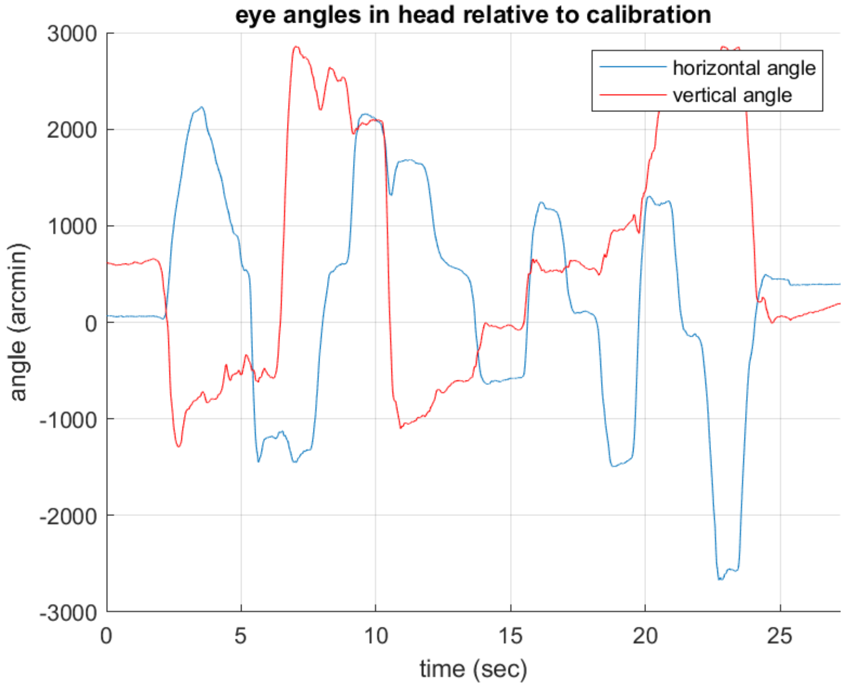
Head fixed 9 points

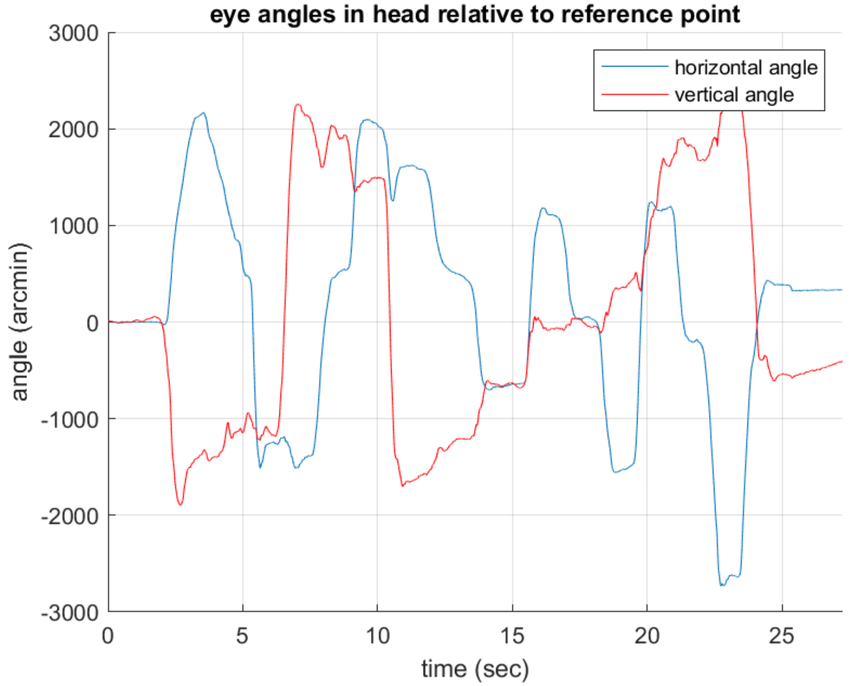




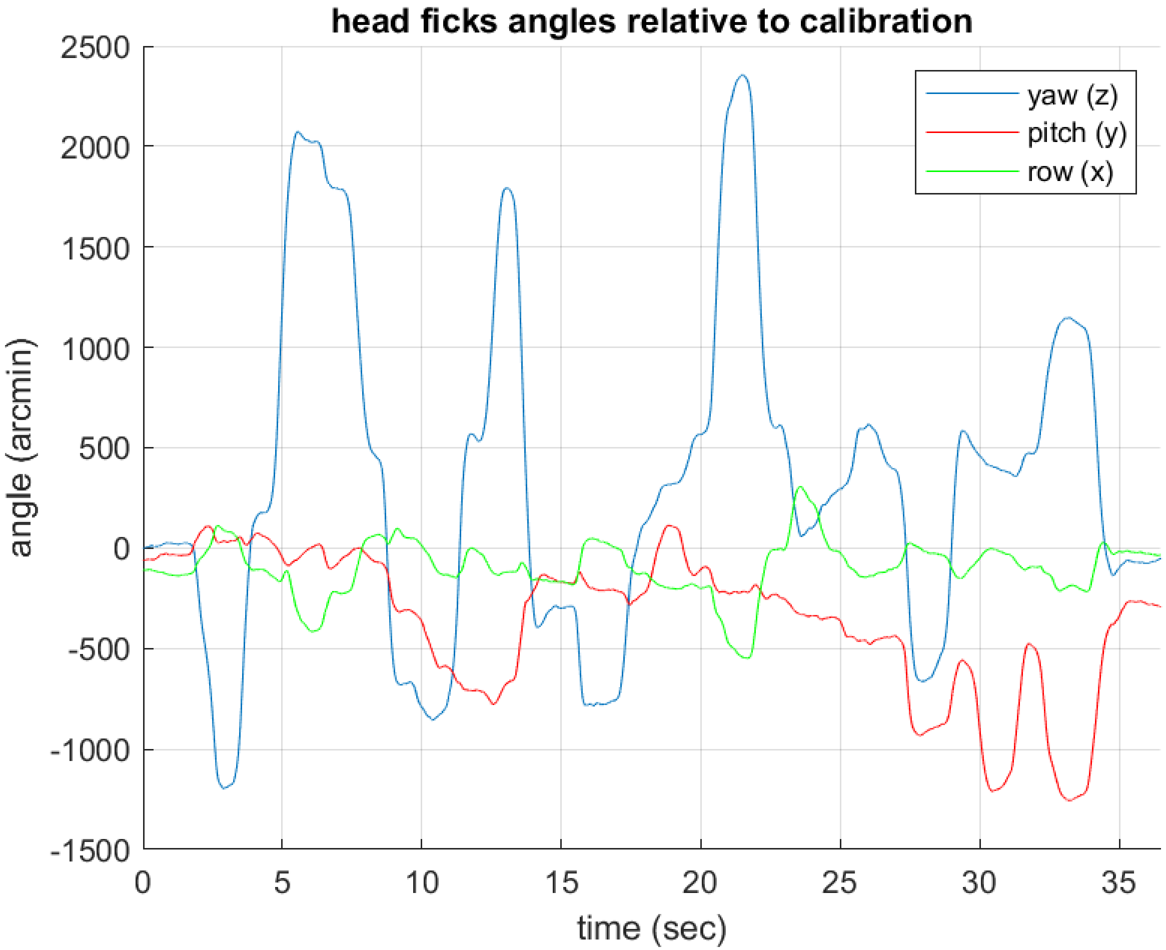
Head fixed 9 points

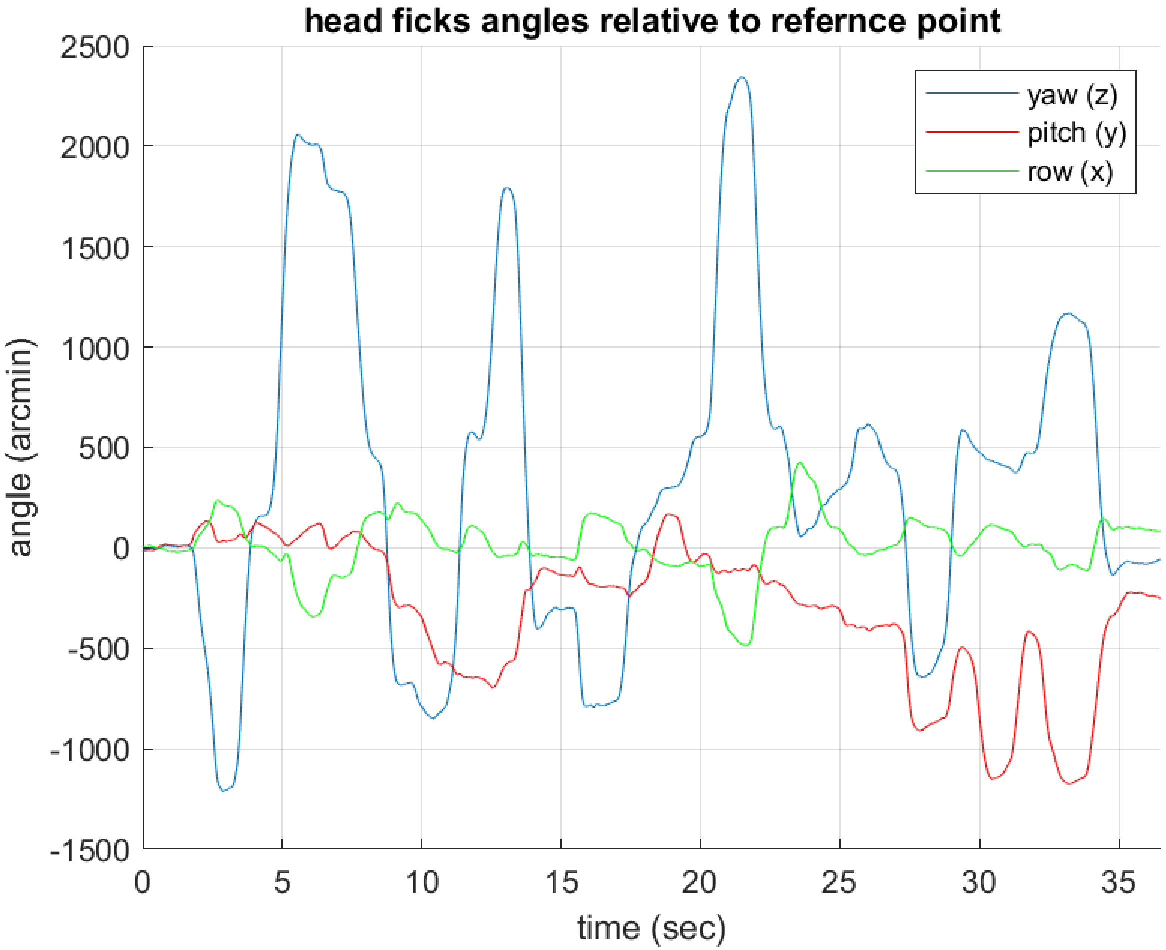




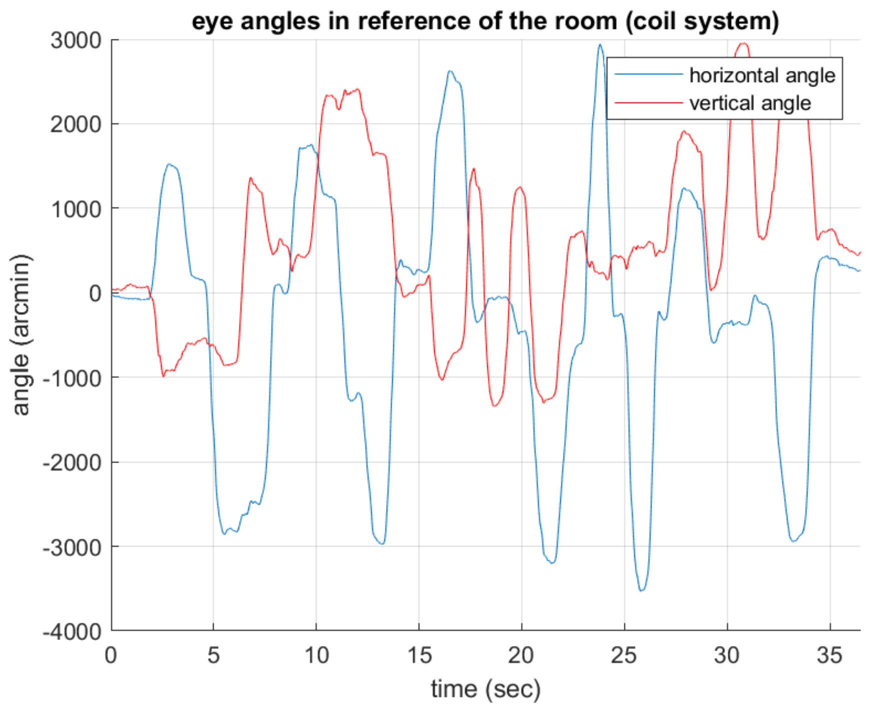


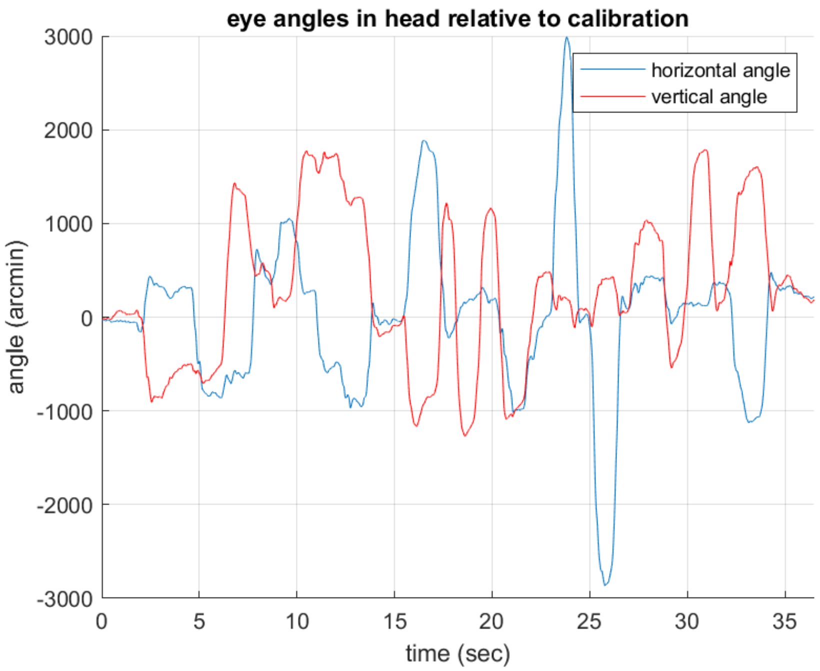
Head free 9 points

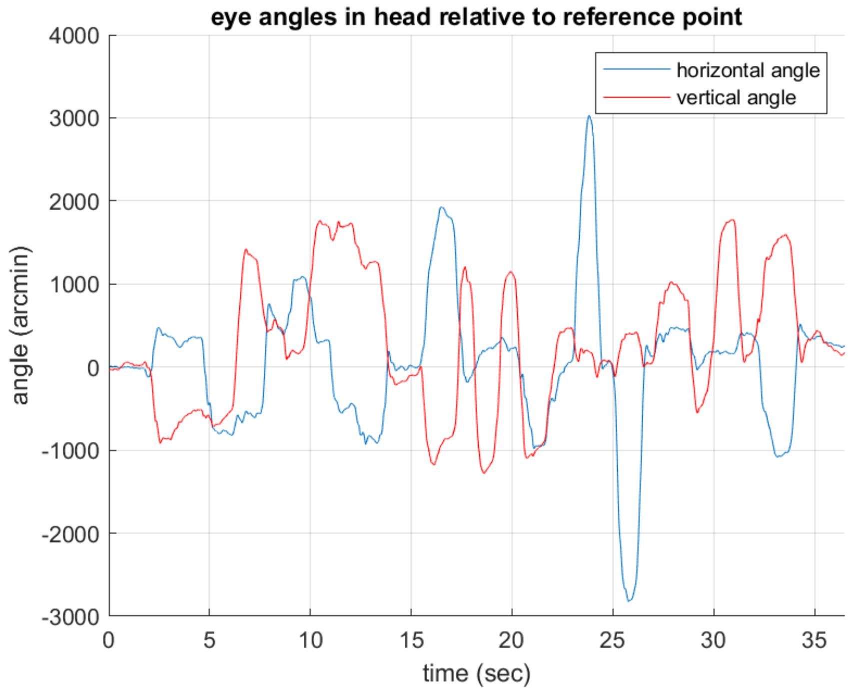




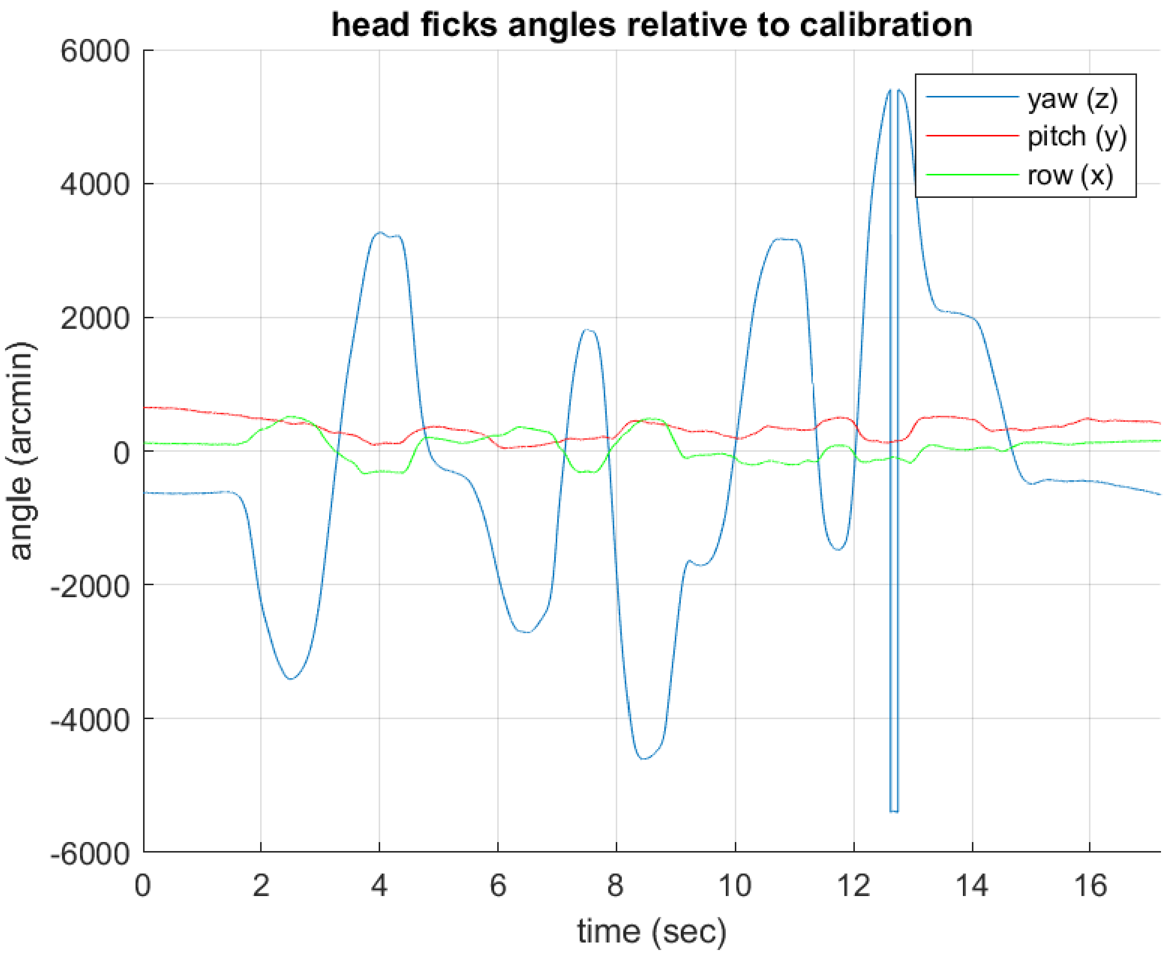
Head free 9 points

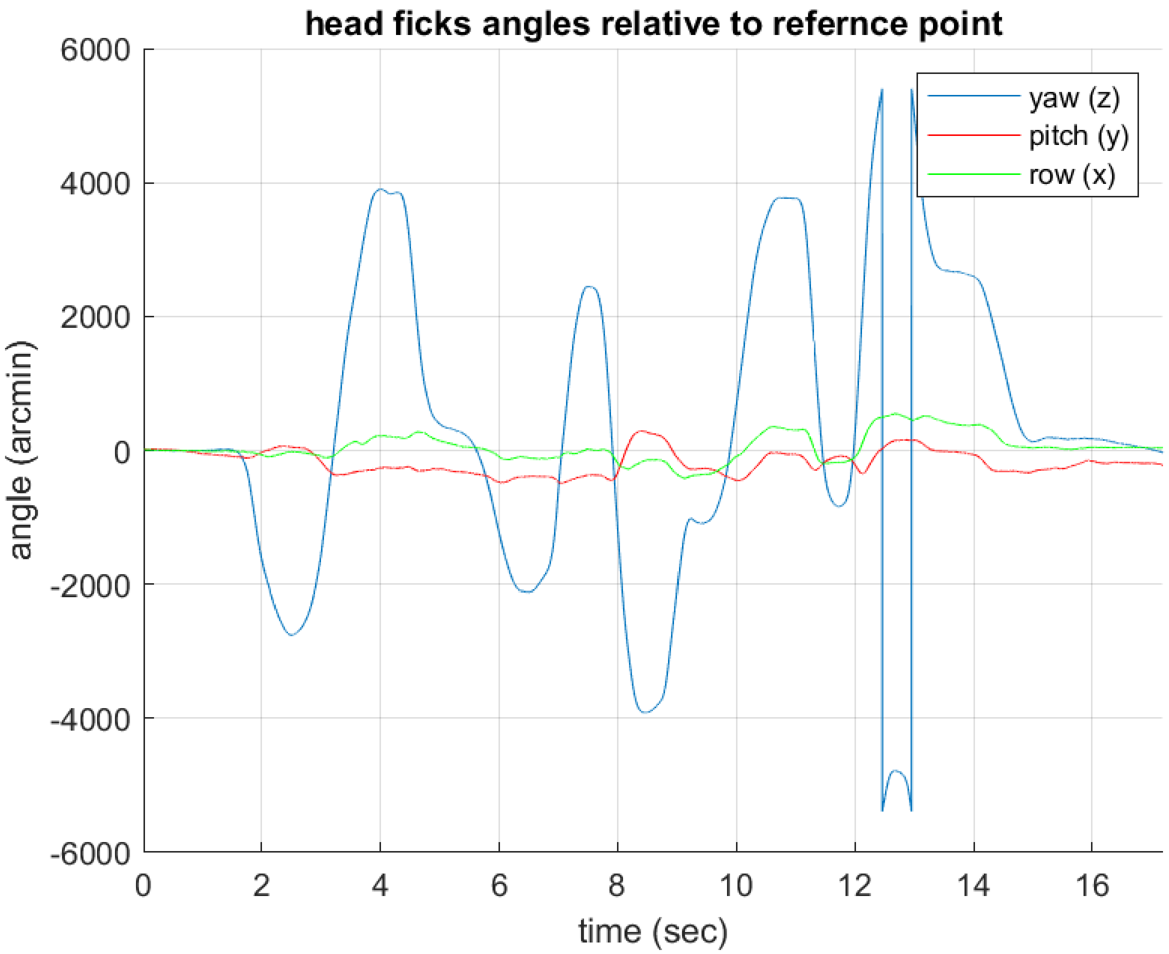




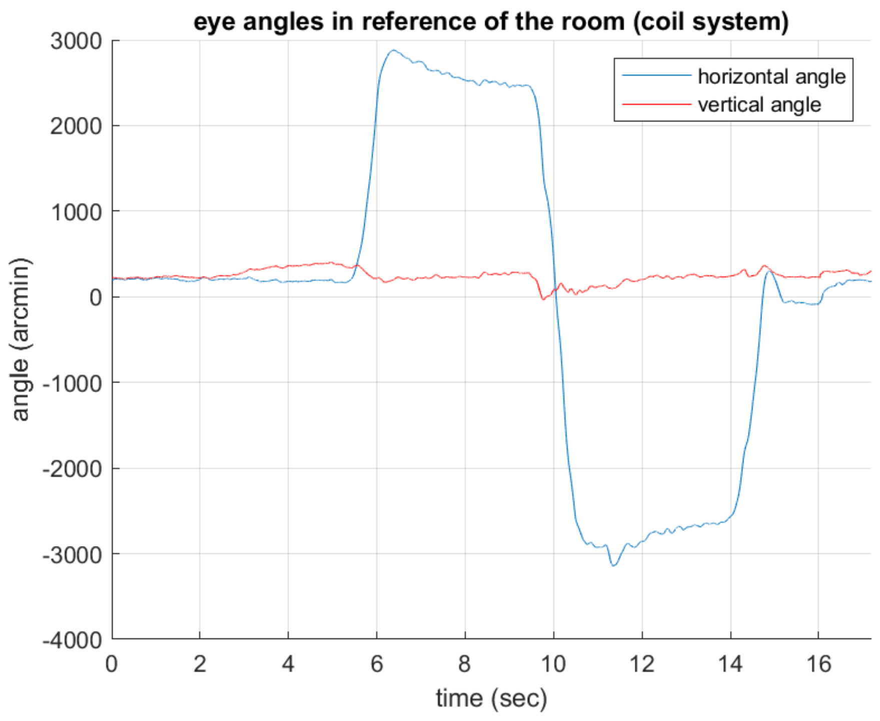


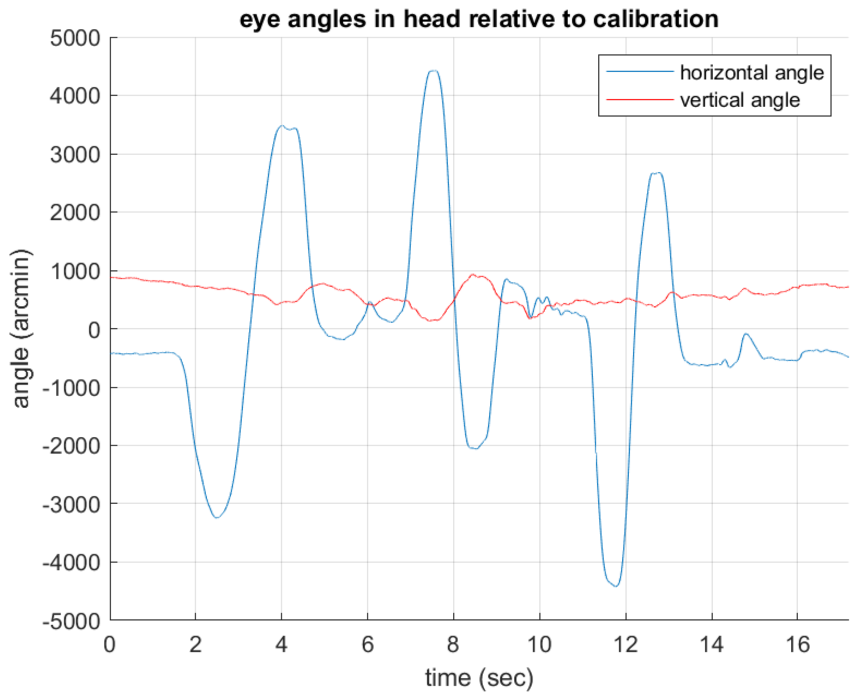
Head and eye opposite motion horizontally

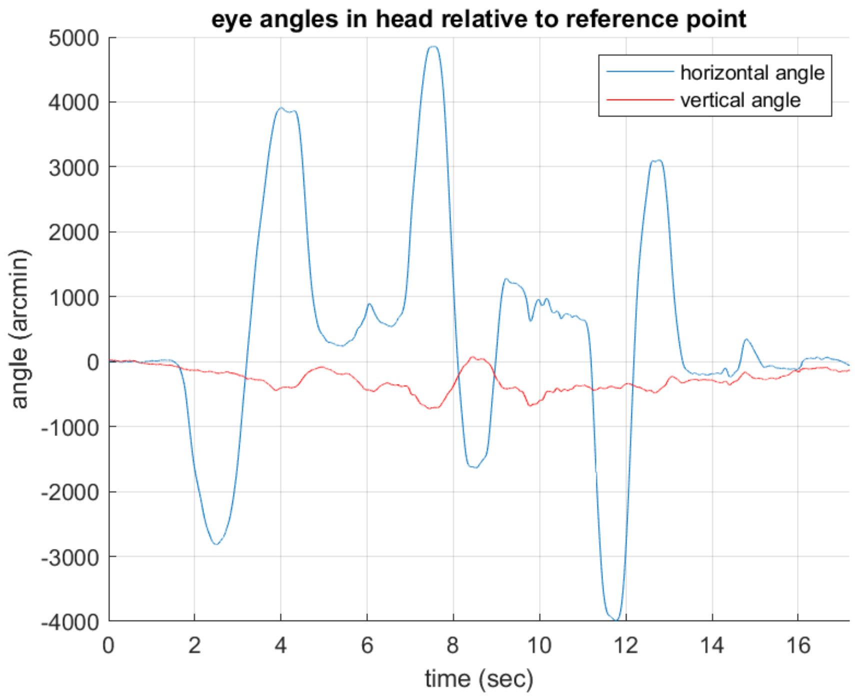




Head and eye opposite motion horizontally







Example of eye movement detection