Measurements of the time-lag of Optotrak system

Carlo Nicolini, Robert Volcic

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1 Measurement method

We measured the time-lag with the method described in Swindell. We used a rotational motor and a rod to stick a marker on it and see the angular displacement from real marker to a corrispondend light point on the display. We rotated the rotor at a speed of $\omega = 1/6$ rpm, equivalent to $\omega = 60°/s$. The time lag Δt accumulated in the whole process, from data acquisition to display, is then simply obtained by the relation $\Delta t = \Delta\theta/\omega$. The $\Delta\theta$ were measured manually with ImageJ software.

We took $N = 20$ measures of the angular distance between the marker infrared emitting diode and a corrispondent white dot with size 8×8 pixels, on a 1024×768 display. The marker was rotating on the focal plane, thus eliminating the parallax error to our best possibilities. We took the photos with a Nikon D90, resolution 3216×2136, ISO 6400, F-number 4.5, Exposure time 1/100, focal length 38 mm. We measured the angles with the camera, calibrated with the center of projection made to correspond to the camera CCD sensor center and frontoparallel to the center of rotation.

Angles were extracted using a manual procedure with ImageJ software. The error bars are the size in angle of the displayed point.

i	$\Delta\theta$ [deg]	$\sigma_{\Delta\theta}$ [deg]	i	$\Delta\theta$ [deg]	$\sigma_{\Delta\theta}$ [deg]
1	0.80	1.07	11	1.90	1.06
2	2.06	0.94	12	1.10	1.16
3	2.15	1.22	13	0.94	1.11
4	2.26	1.25	14	1.70	0.95
5	1.80	1.25	15	2.40	1.01
6	1.80	1.21	16	1.90	1.17
7	1.44	1.02	17	1.70	1.15
8	1.67	1.08	18	1.49	1.14
9	1.96	1.05	19	1.11	1.03
10	1.67	1.15	20	0.41	0.94

Table 1: Table of data for experiment with simple point stimulus

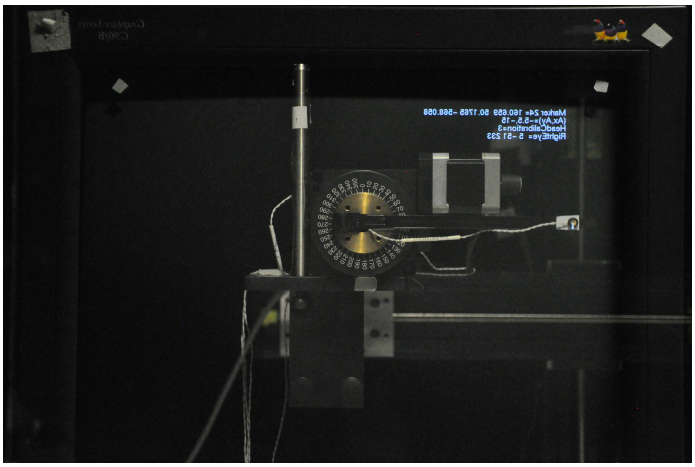

Figure 1: One of the photographs used for the computation

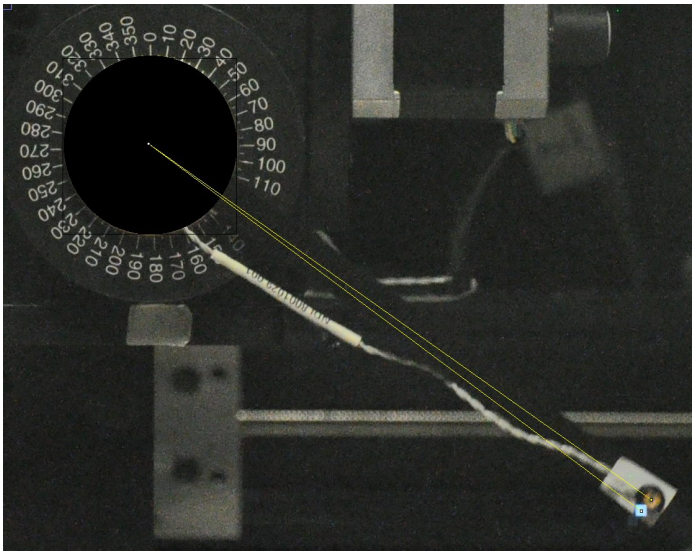

Figure 2: The method of measurement used in ImageJ

2 Analysis

We averaged the measures took at different time intervals.

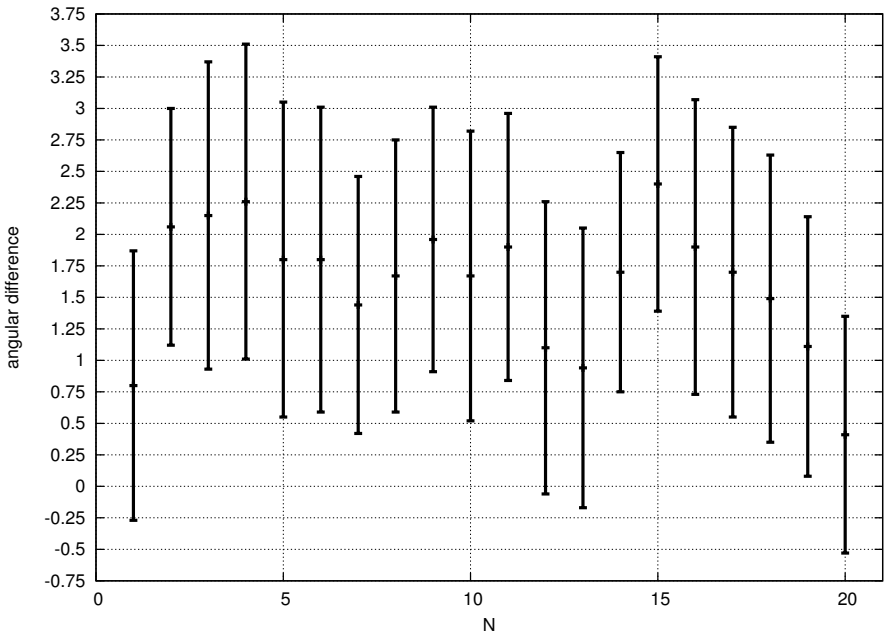

Figure 3: Angular measures and their relative errorbars

The resulting average over $N = 20$ observations of time-lags is $\langle \Delta t \rangle = \langle \Delta \theta \rangle / \omega \approx 0.027$ [s]. The resulting average over $N = 20$ observations of time-lags error is $\langle \sigma_{\Delta t} \rangle = \langle \Delta \theta \rangle / \omega \approx 0.018$ [s]. See table (see 1).

3 Analysis second experiment

We repeated the experiment described before, with a heavier task. We were displaying a complex mesh with more than 10^6 vertices, (see 3) together with the dot and marker in order to check if the system is good also for more complex stimuli.

The resulting time-lag is $\langle \Delta t \rangle = \langle \Delta \theta \rangle / \omega \approx 0.029 \pm 0.074$ [s].

i	$\Delta\theta$ [deg]	$\sigma_{\Delta\theta}$ [deg]	i	$\Delta\theta$ [deg]	$\sigma_{\Delta\theta}$ [deg]
1	0.89	0.90	11	1.82	1.12
2	1.48	1.17	12	1.60	0.97
3	1.86	1.01	13	1.09	1.02
4	1.86	1.01	14	1.38	1.10
5	1.86	1.05	15	2.16	1.02
6	2.16	1.01	16	1.21	1.23
7	2.53	0.97	17	1.26	1.07
8	2.43	1.05	18	1.52	1.10
9	2.21	1.11	19	1.86	1.05
10	2.03	1.06	20	1.57	1.01

Table 2: Table of data for experiment with complex mesh