Supplementary Materials Related to the Article "Evaluation of Inertial Sensor Data by a Comparison with Optical Motion Capture Data of Guitar Strumming Gestures"

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1 Supplementary Figures

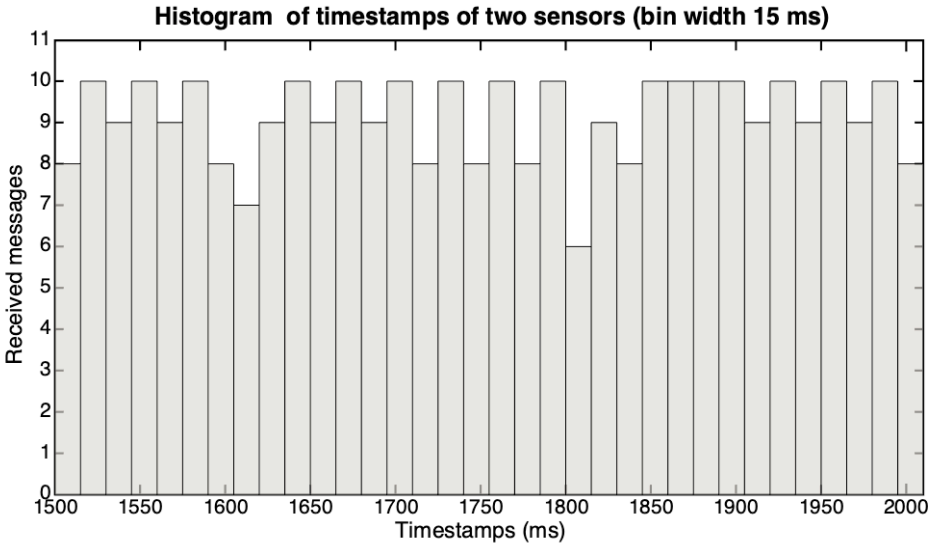

Figure S1: Histogram of timestamps of two sensors with a bin width of 15 ms.

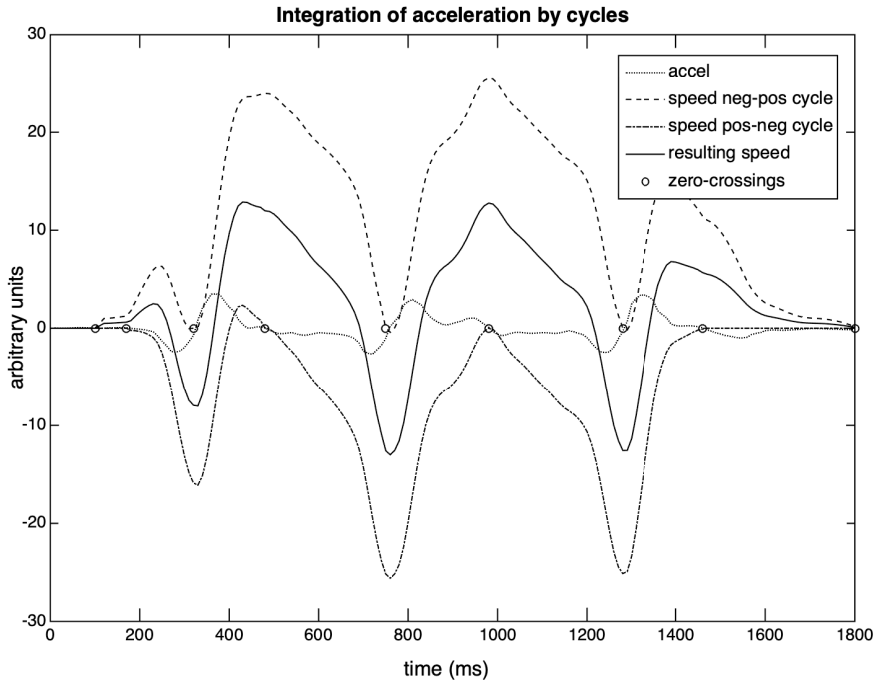

Figure S2: Process of integrating the acceleration by partially overlapping cycles.

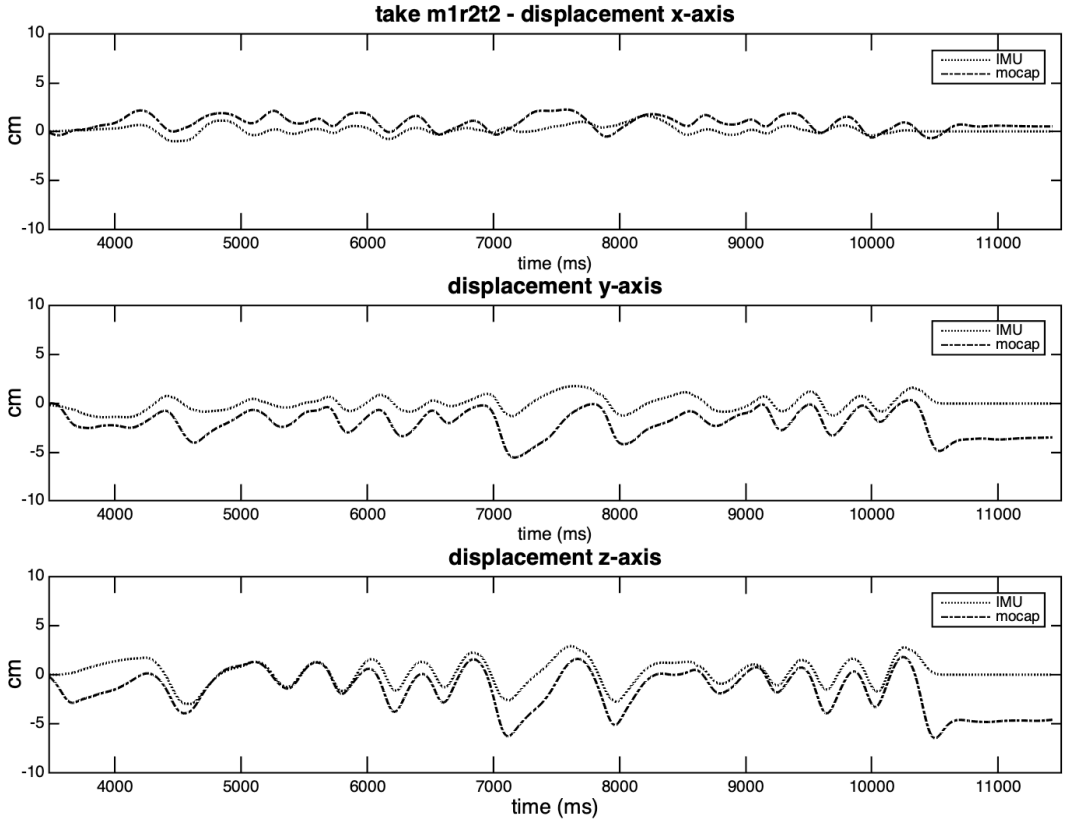

Figure S3: Displacement curves estimated for each axis of take **m1r2t2**, balanced according to the weaker lobe.

2 Data Comparison Tables

2.1 Comparison of Rotational Data

Tables S1 and S2.

Table S1: RMSE and covariances (per axis) between rotational data generated by each system—Musician 1.

take	axis	RMSE (°)	lag	x-covar	mocap mean (°)	stdev	imu mean (°)	stdev
m1r1t1	x	4.42	0	0.997	80.7	17.4	76.5	17.4
	y	0.68	0	0.993	29.1	5.8	29.1	5.7
	z	3.48	-8	0.877	-293.8	6.6	-293.7	5.5
m1r1t2	x	3.97	3	0.989	82.0	19.1	78.5	18.8
	y	1.16	3	0.990	30.3	7.2	29.8	7.0
	z	2.90	-3	0.929	-290.1	8.0	-289.7	6.8
m1r2t1	x	3.24	0	0.993	83.3	17.3	80.9	17.9
	y	1.33	0	0.991	38.6	10.1	38.5	10.1
	z	6.25	-4	0.820	74.4	10.1	73.4	10.0
m1r2t2	x	3.94	0	0.975	89.1	15.3	90.6	16.3
	y	3.28	0	0.989	36.1	8.8	39.1	9.0
	z	6.54	-4	0.744	75.6	8.5	75.5	9.4
m1r3t1a	x	4.43	-1	0.972	-68.3	3.9	-72.5	4.4
	y	2.36	0/-1	0.994	-23.9	7.7	-26.0	7.7
	z	14.47	-1	0.839	-119.7	9.6	-106.9	3.7
m1r3t2a	x	4.27	0	0.966	-76.7	4.8	-80.7	5.5
	y	2.91	0	0.978	-17.9	6.1	-20.5	5.9
	z	14.78	-1	0.898	-123.9	8.2	-110.3	2.9
m1r3t1b	x	7.87	0/-1	0.989	-73.6	9.4	-81.2	8.2
	y	4.64	-1	0.866	-4.0	1.6	0.6	0.9
	z	2.74	-1	0.987	-96.8	9.6	-94.8	9.8
m1r3t2b	x	5.20	0	0.994	-75.4	9.7	-80.0	11.9
	y	11.87	-1	0.924	-4.8	1.4	-16.7	1.2
	z	2.95	0	0.989	-98.9	11.0	-97.5	8.9
m1r3t1c	x	11.09	-1	0.990	-76.8	8.0	-87.8	7.7
	y	1.56	-1	0.990	-1.1	4.1	-2.5	4.0
	z	6.83	-2	0.505	-93.5	4.7	-88.0	2.7
m1r3t2c	x	7.82	-1	0.986	-79.9	9.7	-87.5	9.0
	y	1.28	0	0.992	0.9	5.5	-0.2	5.4
	z	7.82	-12	0.611	-96.8	7.2	-91.6	2.8

Table S2: RMSE and covariances (per axis) between rotational data generated by each system—Musician 2.

take	axis	RMSE (°)	lag	x-covar	mocap mean (°)	stdev	imu mean (°)	stdev
m2r1t1	x	5.00	1/0	0.996	-80.4	19.4	-85.1	19.4
	y	1.19	0	0.995	-41.4	9.1	-40.7	9.6
	z	4.45	-2	0.969	213.8	13.5	214.3	10.2
m2r1t2	x	4.22	2	0.996	-78.1	19.7	-82.2	19.7
	y	1.14	2	0.996	-38.4	8.5	-39.1	8.9
	z	4.37	0	0.974	217.0	13.4	218.7	10.5
m2r2t1	x	6.07	1	0.996	-85.1	14.1	-91.2	13.6
	y	0.79	1	0.997	-44.1	9.8	-44.2	10.0
	z	8.35	-1	0.880	209.9	11.0	205.1	12.3
m2r2t2	x	6.69	-1	0.996	-79.7	14.7	-86.2	14.2
	y	0.79	-1	0.996	-42.3	9.3	-42.4	9.6
	z	5.13	-3	0.890	212.8	10.8	212.3	11.0
m2r3t1a	x	5.63	1/2	0.950	-64.6	5.7	-69.8	5.7
	y	2.83	2	0.972	-27.7	8.9	-29.5	9.0
	z	9.72	6/5	0.711	-150.5	9.3	-143.1	6.9
m2r3t2a	x	5.68	0/1	0.948	-67.8	5.8	-73.1	6.1
	y	2.54	1	0.958	-30.6	7.9	-31.4	8.5
	z	11.20	2/1	0.730	-150.1	7.6	-140.2	6.6
m2r3t1b	x	3.73	2	0.970	-68.7	6.6	-72.3	6.9
	y	2.48	2	0.979	-11.4	6.4	-9.2	6.3
	z	11.02	4/3	0.914	-122.5	9.9	-113.2	4.3
m2r3t2b	x	3.29	0	0.985	-61.4	7.7	-63.6	9.6
	y	7.60	0	0.994	-8.7	9.6	-16.3	9.8
	z	13.39	2/1	0.928	-131.8	11.5	-121.6	3.1
m2r3t1c	x	4.37	3	0.988	-71.5	11.8	-75.5	11.9
	y	2.69	3	0.966	-5.0	5.0	-2.6	5.2
	z	5.17	3	0.662	-116.7	5.8	-113.9	3.3
m2r3t2c	x	4.40	1	0.987	-64.4	11.0	-68.4	11.4
	y	7.64	1	0.993	-5.3	7.1	-12.9	7.4
	z	8.62	0	0.580	-121.6	6.9	-115.2	5.4

2.2 Comparison of Translations

2.2.1 Deriving the Positional Data

Tables S3, S4, S5 and S6.

Table S3: Covariances (per axis) between linear accelerations from IMU and double derivatives of mocap positional data—Musician 1.

axis	**x**		**y**		**z**	
take	**x-covar**	**lag**	**x-covar**	**lag**	**x-covar**	**lag**
m1r1t1	0.808	1	0.948	0	0.978	-1
m1r1t2	0.709	-2	0.895	-3	0.967	-3
m1r2t1	0.854	0	0.948	-1	0.968	-1
m1r2t2	0.843	0	0.955	0	0.955	0
m1r3t1a	0.952	0	0.899	1	0.973	0
m1r3t1b	0.809	0	0.970	0	0.936	1
m1r3t1c	0.719	-1	0.788	0	0.627	1
m1r3t2a	0.973	-1	0.919	0	0.975	0
m1r3t2b	0.911	-1	0.934	0	0.911	0
m1r3t2c	0.677	-3	0.768	0	0.638	1

Table S4: RMSE and maximal ranges (per axis) in the comparison of acceleration data of both systems—Musician 1.

axis	**x**			**y**			**z**		
	RMSE	**Δmax**		**RMSE**	**Δmax**		**RMSE**	**Δmax**	
take	(m/s^2)	**mocap**	**imu**	(m/s^2)	**mocap**	**imu**	(m/s^2)	**mocap**	**imu**
m1r1t1	0.98	5.32	7.40	0.66	10.83	10.73	0.82	16.19	15.40
m1r1t2	1.30	5.94	8.23	0.98	9.71	9.46	0.96	15.73	15.51
m1r2t1	0.61	6.54	6.77	0.77	12.85	12.88	0.72	15.57	15.83
m1r2t2	1.02	6.26	9.43	0.62	12.59	14.04	0.91	15.15	17.24
m1r3t1a	0.49	8.23	8.15	0.89	14.05	10.02	0.33	8.65	9.45
m1r3t1b	3.46	22.72	13.05	1.34	13.75	13.07	1.59	10.85	13.08
m1r3t1c	1.73	14.30	6.96	1.17	10.09	11.9	1.05	7.37	6.11
m1r3t2a	0.65	9.21	6.80	0.86	14.64	10.64	0.40	8.99	10.77
m1r3t2b	2.73	24.70	13.31	2.27	14.70	21.89	1.06	9.89	9.81
m1r3t2c	1.82	14.24	6.45	1.16	10.41	9.76	1.17	8.75	7.35

Table S5: Covariances (per axis) between linear accelerations from IMU and double derivatives of mocap positional data—Musician 2.

axis	**x**		**y**		**z**	
take	**x-covar**	**lag**	**x-covar**	**lag**	**x-covar**	**lag**
m2r1t1	0.478	-3	0.950	0	0.979	0
m2r1t2	0.549	-3	0.876	-2	0.970	-2
m2r2t1	0.246	-2	0.932	0	0.980	-1
m2r2t2	0.447	0	0.956	1	0.989	1
m2r3t1a	0.929	-3	0.690	-3	0.985	-3
m2r3t1b	0.806	-4	0.402	-4	0.929	-3
m2r3t1c	0.743	-4	0.730	-4	0.763	-3
m2r3t2a	0.787	-2	0.930	-2	0.955	-2
m2r3t2b	0.679	-1	0.658	-1	0.848	-1
m2r3t2c	0.753	-1	0.738	-1	0.837	-1

Table S6: RMSE and maximal ranges (per axis) in the comparison of acceleration data of both systems—Musician 2.

axis		**x**			**y**			**z**	
	RMSE	**Δmax**		**RMSE**	**Δmax**		**RMSE**	**Δmax**	
take	(m/s^2)	**mocap**	**imu**	(m/s^2)	**mocap**	**imu**	(m/s^2)	**mocap**	**imu**
m2r1t1	0.58	2.61	3.27	0.99	10.83	12.76	0.85	12.78	11.65
m2r1t2	0.63	2.41	3.64	1.43	10.33	11.87	0.91	13.53	14.07
m2r2t1	1.58	5.22	7.26	1.42	13.06	13.97	1.24	19.09	17.19
m2r2t2	1.00	4.73	5.04	1.03	12.71	13.61	0.83	17.74	17.82
m2r3t1a	0.90	9.77	11.08	1.74	15.38	8.48	0.61	13.26	10.99
m2r3t1b	2.03	12.61	8.73	2.13	10.55	4.51	1.23	13.34	13.13
m2r3t1c	1.76	12.70	10.85	1.78	15.26	15.81	1.35	10.76	10.03
m2r3t2a	0.99	7.45	7.13	0.98	14.79	9.06	0.72	11.09	11.11
m2r3t2b	2.27	11.69	10.76	2.33	9.87	12.15	1.98	15.98	13.22
m2r3t2c	1.55	11.28	11.69	2.19	12.14	17.26	1.35	13.43	11.65

2.2.2 Integrating the Acceleration Data

Tables S7, S8, S9 and S10 for individual axes. Tables S11 and S12 for moduli.

Table S7: Covariances (per axis) between mocap positional data and double integrated IMU data—Musician 1.

axis	**x**		**y**		**z**	
take	**x-covar**	**lag**	**x-covar**	**lag**	**x-covar**	**lag**
			(stronger lobe)			
m1r1t1	0.306	-4	0.833	-1	0.897	-1
m1r1t2	0.605	-2	0.820	-3	0.865	-3
m1r2t1	0.499	0	0.515	-1	0.547	-1
m1r2t2	0.116	-1	0.603	0	0.673	0
			(weaker lobe)			
m1r1t1	0.316	-2	0.841	0	0.925	-1
m1r1t2	0.313	-4	0.798	-3	0.875	-3
m1r2t1	0.468	0	0.647	-2	0.653	-1
m1r2t2	0.451	0	0.526	-1	0.672	0

Table S8: Covariances (per axis) between mocap positional data and double integrated IMU data—Musician 2.

axis	**x**		**y**		**z**	
take	**x-covar**	**lag**	**x-covar**	**lag**	**x-covar**	**lag**
			(stronger lobe)			
m2r1t1	0.169	-12	0.841	-1	0.844	0
m2r1t2	0.402	2	0.852	-3	0.829	-2
m2r2t1	0.107	-5	0.843	-1	0.840	-1
m2r2t2	0.075	-1	0.831	0	0.870	1
			(weaker lobe)			
m2r1t1	0.258	-12	0.807	-1	0.872	0
m2r1t2	0.506	6	0.781	-3	0.837	-2
m2r2t1	0.138	-6	0.777	-1	0.856	-1
m2r2t2	0.213	-1	0.819	1	0.889	1

Table S9: RMSE and maximal ranges (per axis and method) in the comparison of displacement data of both systems—Musician 1.

axis	**x**			**y**			**z**		
	RMSE	**Δmax**		**RMSE**	**Δmax**		**RMSE**	**Δmax**	
take	(*cm*)	**mocap**	**imu**	(*cm*)	**mocap**	**imu**	(*cm*)	**mocap**	**imu**
				(stronger lobe)					
m1r1t1	1.11	1.751	6.19	0.67	2.96	4.20	1.79	7.26	9.00
m1r1t2	0.93	1.842	2.64	1.62	3.48	6.55	2.56	6.96	9.75
m1r2t1	0.85	2.528	3.13	2.23	5.93	8.87	2.43	8.73	18.10
m1r2t2	3.23	2.926	16.56	2.89	5.86	15.90	2.62	8.28	16.76
				(weaker lobe)					
m1r1t1	0.52	1.751	1.28	0.54	2.96	2.52	1.54	7.26	5.13
m1r1t2	0.89	1.842	1.87	1.52	3.48	2.81	2.48	6.96	5.81
m1r2t1	0.81	2.528	1.43	1.62	5.93	3.21	1.66	8.73	5.30
m1r2t2	1.21	2.926	2.55	2.37	5.86	3.18	1.96	8.28	5.90

Table S10: RMSE and maximal ranges (per axis and method) in the comparison of displacement data of both systems—Musician 2.

axis	**x**			**y**			**z**		
	RMSE	**Δmax**		**RMSE**	**Δmax**		**RMSE**	**Δmax**	
take	(*cm*)	**mocap**	**imu**	(*cm*)	**mocap**	**imu**	(*cm*)	**mocap**	**imu**
				(stronger lobe)					
m2r1t1	0.67	0.882	3.43	1.94	4.75	7.49	1.29	7.94	8.86
m2r1t2	0.62	0.872	2.68	1.45	4.84	8.22	1.43	8.07	9.47
m2r2t1	1.96	2.210	9.11	1.31	5.13	8.91	3.08	9.17	10.67
m2r2t2	0.62	2.172	2.71	2.58	5.35	6.66	1.34	8.42	8.66
				(weaker lobe)					
m2r1t1	0.26	0.882	0.98	1.44	4.75	3.97	1.11	7.94	5.58
m2r1t2	0.23	0.872	1.20	0.98	4.84	3.47	1.44	8.07	6.26
m2r2t1	1.20	2.210	1.68	0.95	5.13	3.78	3.13	9.17	6.12
m2r2t2	0.47	2.172	1.15	2.44	5.35	3.78	1.32	8.42	6.23

Table S11: Covariances between displacement magnitude of each system with two different rotation matrices and two integration methods—musicians 1 and 2.

take	**mocap-rotated**		**IMU-rotated**	
	(s. lobe)	(w. lobe)	(s. lobe)	(w. lobe)
m1r1t1	0.868	0.918	0.863	0.902
m1r1t2	0.868	0.882	0.807	0.804
m1r2t1	0.622	0.705	0.592	0.729
m1r2t2	0.558	0.685	0.174	0.722
m2r1t1	0.834	0.871	0.675	0.747
m2r1t2	0.814	0.836	0.656	0.733
m2r2t1	0.766	0.846	0.765	0.848
m2r2t2	0.886	0.886	0.759	0.882

Table S12: RMSE and maximal ranges in the comparison of displacement moduli of each system with two different rotation matrices and two integration methods—musicians 1 and 2.

take	**RMSE** (cm)		**Δmax** (cm)		
	(s. lobe)	**(w. lobe)**	**mocap**	**(s. lobe)**	**(w. lobe)**
			(mocap-rotated)		
m1r1t1	3.80	0.74	6.19	9.90	4.77
m1r1t2	3.86	0.99	6.09	10.25	5.34
m1r2t1	7.55	1.14	6.46	16.81	5.08
m1r2t2	11.65	1.24	6.85	19.01	6.01
m2r1t1	3.77	1.18	5.72	9.91	5.72
m2r1t2	4.73	1.51	5.92	10.96	5.41
m2r2t1	6.95	1.19	7.09	13.64	6.49
m2r2t2	3.33	1.15	6.40	9.43	6.56
			(imu-rotated)		
m1r1t1	3.04	0.93	6.19	6.26	3.45
m1r1t2	3.34	1.22	6.09	6.83	4.38
m1r2t1	10.02	1.19	6.46	22.07	4.64
m1r2t2	17.43	1.34	6.85	25.45	4.12
m2r1t1	2.84	1.49	5.72	4.95	3.34
m2r1t2	3.07	1.61	5.92	3.98	3.49
m2r2t1	3.07	1.61	7.09	5.07	4.12
m2r2t2	2.66	1.40	6.40	4.43	4.07