

# **Validation of a Single RGB-D Camera for Gait Assessment of Polyneuropathy Patients**

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## **Supplementary Data**

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# **Gait cycle detection**

Window size choice

**Table S1. Results obtained when filtering the ankle distance measure using a moving average filter with a window of size NF1, and estimating the heel strike instants using a window of size ND1 (Kinect data), for different window sizes. The results corresponding to the chosen window size pair are underlined.**

NF1	ND1	Precision (%)	Sensitivity (%)	Absolute Error (ms)
1	3	50.9	96.0	51.3 ± 35.1
1	5	89.8	69.8	61.6 ± 40.4
1	7	95.1	48.6	61.0 ± 40.2
1	9	96.0	42.0	58.6 ± 37.4
3	3	81.9	94.4	48.2 ± 35.4
3	5	93.6	89.8	51.6 ± 37.8
3	7	95.9	86.0	50.7 ± 36.7
3	9	97.4	82.0	50.3 ± 36.7
5	3	90.8	95.4	42.9 ± 38.7
5	5	96.7	91.6	41.6 ± 36.3
5	7	97.8	91.0	41.2 ± 35.9
5	9	97.9	90.0	41.1 ± 35.8
7	3	93.6	95.1	40.2 ± 38.2
7	5	96.7	94.1	39.9 ± 37.6
7	7	<u>98.4</u>	<u>91.9</u>	<u>37.8 ± 33.7</u>
7	9	98.4	91.5	37.9 ± 33.8
9	3	94.4	94.4	39.1 ± 33.9
9	5	96.9	93.1	39.2 ± 33.9
9	7	97.5	92.5	38.7 ± 33.0
9	9	98.4	91.3	37.7 ± 30.9

**Table S2. Results obtained when filtering the ankle velocity measures using a moving average filter with a window of size NF2, and identifying the side of the heel strikes using a window of size ND2 (Kinect data), for different window sizes. The results corresponding to the chosen window size pair are underlined.**

NF2	ND2	Precision (%)			Sensitivity (%)			Mean (Precision & Sensitivity) (%)
		Left	Right	Mean	Left	Right	Mean	
<b>1</b>	<b>3</b>	76.4	73.9	75.1	73.6	77.3	75.4	75.3
<b>1</b>	<b>5</b>	84.4	87.2	85.8	87.8	84.4	86.1	86.0
<b>1</b>	<b>7</b>	95.1	94.6	94.8	94.5	95.2	94.8	94.8
<b>1</b>	<b>9</b>	97.4	97.1	97.3	97.1	97.4	97.3	97.3
<b>3</b>	<b>3</b>	86.7	86.0	86.3	85.8	87.1	86.5	86.4
<b>3</b>	<b>5</b>	95.7	94.6	95.2	94.8	95.8	95.3	95.2
<b>3</b>	<b>7</b>	98.4	98.1	98.2	98.0	98.4	98.2	98.2
<b>3</b>	<b>9</b>	99.0	98.4	98.7	98.4	99.0	98.7	98.7
<b>5</b>	<b>3</b>	94.3	97.0	95.7	97.1	94.2	95.6	95.7
<b>5</b>	<b>5</b>	98.0	97.4	97.7	97.7	98.1	97.9	97.8
<b>5</b>	<b>7</b>	98.4	98.7	98.5	98.7	98.4	98.5	98.5
<b>5</b>	<b>9</b>	99.0	100	99.5	100	99.0	99.5	99.5
<b>7</b>	<b>3</b>	98.0	97.5	97.7	97.4	98.1	97.7	97.7
<b>7</b>	<b>5</b>	98.7	99.0	98.9	99.0	98.7	98.9	98.9
<b>7</b>	<b>7</b>	99.3	99.4	99.4	99.3	99.4	99.4	99.4
<b>7</b>	<b>9</b>	99.4	99.7	99.5	99.7	99.4	99.5	99.5
<b>9</b>	<b>3</b>	99.0	99.4	99.2	99.3	99.0	99.2	99.2
<b>9</b>	<b>5</b>	99.7	99.7	99.7	99.7	99.7	99.7	99.7
<b>9</b>	<b>7</b>	99.7	99.7	99.7	99.7	99.7	99.7	99.7
<b>9</b>	<b>9</b>	99.3	99.4	99.4	99.3	99.4	99.4	99.4
<b>11</b>	<b>3</b>	99.3	99.4	99.4	99.3	99.4	99.4	99.4
<b>11</b>	<b>5</b>	99.4	99.7	99.5	99.7	99.4	99.5	99.5
<b>11</b>	<b>7</b>	99.4	99.7	99.5	99.7	99.4	99.5	99.5
<b>11</b>	<b>9</b>	99.4	100	99.7	100	99.4	99.7	99.7
<b>13</b>	<b>3</b>	99.4	99.7	99.5	99.7	99.4	99.5	99.5
<b>13</b>	<b>5</b>	99.7	99.7	99.7	99.7	99.7	99.7	99.7
<b>13</b>	<b>7</b>	99.7	100	99.8	100	99.7	99.8	99.8
<b>13</b>	<b>9</b>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
<b>15</b>	<b>3</b>	99.4	99.7	99.5	99.7	99.4	99.5	99.5
<b>15</b>	<b>5</b>	99.7	99.7	99.7	99.7	99.7	99.7	99.7
<b>15</b>	<b>7</b>	99.7	100	99.8	100	99.7	99.8	99.8
<b>15</b>	<b>9</b>	100	100	100	100	100	100	100

**Table S3. Results obtained when filtering the shank angle measures using a moving average filter with a window of size NF3 (Kinect data), for different window sizes. The results corresponding to the chosen window size are underlined.**

NF3	Sensitivity (%)	Absolute Error (ms)			
		Stance duration	Swing duration	Single support duration	Double support duration
<b>1</b>	98.5	63.7 ± 53.8	63.7 ± 52.2	108.9 ± 74.8	108.6 ± 85.6
<b>3</b>	98.1	58.5 ± 50.9	60.0 ± 50.1	103.0 ± 70.9	102.0 ± 79.4
<b>5</b>	98.1	58.3 ± 50.6	59.9 ± 49.0	103.0 ± 69.7	102.1 ± 78.0
<b>7</b>	97.9	56.3 ± 49.2	57.6 ± 45.9	101.1 ± 65.8	99.9 ± 77.2
<b>9</b>	<u>98.1</u>	<u>56.8 ± 49.6</u>	<u>58.1 ± 45.8</u>	<u>101.0 ± 66.0</u>	<u>100.0 ± 78.7</u>
<b>11</b>	98.1	60.5 ± 49.1	61.5 ± 46.3	111.5 ± 66.5	109.6 ± 78.5

# **Gait parameter computation**

Butterworth filter parameter choice (Kinect)

**Table S4. Butterworth filter’s order and cut-off frequency values used for computing gait parameters from Kinect data.**

<b>Gait parameter</b>	<b>Order</b>	<b>Cut-off frequency (Hz)</b>
<b>Stride length</b>		
<b>Step length</b>		Not filtered
<b>Step width</b>		
<b>Gait speed</b>		
<b>Gait speed variability</b>	6	4
<b>Foot swing velocity</b>		
<b>Arm swing velocity</b>		3
<b>TBCM<sup>a</sup> sway x-component</b>	2	1
<b>TBCM<sup>a</sup> sway y-component</b>		Not filtered
<b>Spine shoulder angle</b>		Not filtered
<b>Spine middle angle</b>		
<b>Elbow angle maximum</b>	2	1
<b>Elbow angle minimum</b>		Not filtered
<b>Knee angle maximum</b>	6	3
<b>Knee angle minimum</b>		Not filtered
<b>Hip angle range</b>	6	3
<b>Ankle angle range</b>		1

<sup>a</sup>TBCM stands for total body center of mass.

**Table S5. Mean absolute error between Kinect and Qualisys for the spatiotemporal gait parameters, without filtering and when varying the Butterworth filter's order between 2 and 6 (even integer values), and cut-off frequency between 1 and 9 Hz (integer values). The result corresponding to the chosen value pair for each gait parameter is underlined.**

Order	Cut-off frequency (Hz)	Stride length (cm)	Step length (cm)	Step width (cm)	Gait speed (m/s)	Gait speed variability (m/s)	Foot swing velocity (m/s)	Arm swing velocity (m/s)	Total body center of mass sway (mm <sup>2</sup> )	
									x-component	y-component
	<b>No filter</b>	<u>1.53</u>	<u>2.78</u>	<u>1.02</u>	0.014	0.073	0.983	0.285	0.219	<u>0.044</u>
2	<b>1</b>	1.53	3.37	10.70	0.019	0.037	0.628	0.219	<u>0.179</u>	0.099
2	<b>2</b>	1.53	2.88	5.49	0.015	0.015	0.339	0.125	0.200	0.069
2	<b>3</b>	1.53	2.72	3.31	0.014	0.011	0.247	0.104	0.209	0.057
2	<b>4</b>	1.53	2.71	2.22	0.014	0.011	0.260	0.105	0.214	0.052
2	<b>5</b>	1.53	2.70	1.61	0.014	0.014	0.330	0.116	0.216	0.049
2	<b>6</b>	1.53	2.70	1.28	0.014	0.021	0.421	0.135	0.217	0.047
2	<b>7</b>	1.53	2.67	1.10	0.014	0.031	0.530	0.162	0.218	0.046
2	<b>8</b>	1.53	2.69	1.02	0.014	0.044	0.662	0.196	0.219	0.045
2	<b>9</b>	1.53	2.74	1.00	0.014	0.060	0.832	0.242	0.219	0.044
4	<b>1</b>	1.53	4.89	12.6	0.016	0.045	0.697	0.219	0.195	0.107
4	<b>2</b>	1.53	3.17	5.54	0.013	0.013	0.369	0.107	0.213	0.064
4	<b>3</b>	1.53	2.88	2.82	0.013	0.011	0.237	0.094	0.217	0.051
4	<b>4</b>	1.53	2.72	1.78	0.013	0.011	0.223	0.098	0.218	0.047
4	<b>5</b>	1.53	2.77	1.33	0.013	0.012	0.263	0.106	0.218	0.046
4	<b>6</b>	1.53	2.70	1.12	0.014	0.013	0.325	0.119	0.218	0.045
4	<b>7</b>	1.53	2.66	1.04	0.014	0.017	0.405	0.135	0.219	0.045
4	<b>8</b>	1.53	2.69	1.00	0.014	0.027	0.494	0.157	0.219	0.045
4	<b>9</b>	1.53	2.76	0.99	0.014	0.041	0.596	0.183	0.219	0.045
6	<b>1</b>	1.53	6.91	13.49	0.016	0.051	0.693	0.218	0.200	0.111
6	<b>2</b>	1.53	3.36	5.75	0.013	0.013	0.387	0.103	0.215	0.061
6	<b>3</b>	1.53	3.00	2.71	0.013	0.011	0.233	<u>0.091</u>	0.217	0.049
6	<b>4</b>	1.53	2.75	1.68	<u>0.013</u>	<u>0.011</u>	<u>0.215</u>	0.096	0.218	0.046
6	<b>5</b>	1.53	2.72	1.29	0.013	0.012	0.248	0.104	0.218	0.046
6	<b>6</b>	1.53	2.75	1.11	0.014	0.012	0.299	0.115	0.218	0.045
6	<b>7</b>	1.53	2.68	1.03	0.014	0.014	0.368	0.129	0.219	0.045
6	<b>8</b>	1.53	2.71	1.00	0.014	0.021	0.450	0.148	0.219	0.045
6	<b>9</b>	1.53	2.71	0.99	0.014	0.034	0.539	0.172	0.219	0.045



**Table S6. Mean absolute error between Kinect and Qualisys for the kinematic gait parameters, without filtering and when varying the Butterworth filter's order between 2 and 6 (even integer values), and cut-off frequency between 1 and 9 Hz (integer values). The result corresponding to the chosen value pair for each gait parameter is underlined.**

Order	Cut-off frequency (Hz)	Mean angle (deg.)		Elbow angle (deg.)		Knee angle (deg.)		Angle range (deg.)	
		Spine shoulder	Spine middle	Maximum	Minimum	Maximum	Minimum	Hip	Ankle
	<b>No filter</b>	<u>4.08</u>	<u>14.69</u>	5.74	<u>5.67</u>	5.04	<u>7.54</u>	5.45	41.22
<b>2</b>	<b>1</b>	4.08	14.69	<u>5.03</u>	7.71	5.14	19.79	7.62	12.62
<b>2</b>	<b>2</b>	4.08	14.69	5.04	6.66	4.79	12.72	4.53	20.21
<b>2</b>	<b>3</b>	4.08	14.69	5.06	6.33	4.81	10.32	4.25	25.38
<b>2</b>	<b>4</b>	4.08	14.69	5.09	6.16	4.85	9.32	4.50	29.27
<b>2</b>	<b>5</b>	4.08	14.69	5.15	6.05	4.88	8.81	4.74	32.63
<b>2</b>	<b>6</b>	4.08	14.69	5.21	5.97	4.92	8.47	4.95	35.66
<b>2</b>	<b>7</b>	4.08	14.69	5.28	5.90	4.95	8.22	5.12	38.37
<b>2</b>	<b>8</b>	4.08	14.69	5.37	5.82	4.99	7.99	5.26	40.82
<b>2</b>	<b>9</b>	4.08	14.69	5.53	5.72	5.04	7.74	5.39	42.77
<b>4</b>	<b>1</b>	4.08	14.69	5.11	7.83	5.10	22.35	9.88	11.84
<b>4</b>	<b>2</b>	4.07	14.69	5.08	6.55	4.81	11.68	4.76	19.57
<b>4</b>	<b>3</b>	4.08	14.69	5.06	6.26	4.79	8.83	4.23	25.01
<b>4</b>	<b>4</b>	4.08	14.69	5.08	6.15	4.82	8.43	4.62	29.08
<b>4</b>	<b>5</b>	4.08	14.69	5.11	6.07	4.87	8.41	4.87	32.21
<b>4</b>	<b>6</b>	4.08	14.69	5.16	6.02	4.91	8.35	5.02	34.92
<b>4</b>	<b>7</b>	4.08	14.69	5.22	5.97	4.94	8.26	5.11	37.53
<b>4</b>	<b>8</b>	4.08	14.69	5.29	5.92	4.96	8.14	5.19	39.97
<b>4</b>	<b>9</b>	4.08	14.69	5.35	5.85	4.99	8.00	5.28	41.77
<b>6</b>	<b>1</b>	4.08	14.69	5.15	7.93	5.13	23.83	10.86	<u>11.45</u>
<b>6</b>	<b>2</b>	4.07	14.69	5.11	6.50	4.87	11.59	4.91	19.36
<b>6</b>	<b>3</b>	4.08	14.69	5.06	6.25	<u>4.78</u>	8.23	<u>4.22</u>	24.64
<b>6</b>	<b>4</b>	4.08	14.69	5.07	6.14	4.80	8.16	4.66	29.00
<b>6</b>	<b>5</b>	4.08	14.69	5.11	6.07	4.86	8.40	4.91	32.35
<b>6</b>	<b>6</b>	4.08	14.69	5.14	6.03	4.91	8.39	5.03	34.87
<b>6</b>	<b>7</b>	4.08	14.69	5.19	5.99	4.94	8.29	5.11	37.26
<b>6</b>	<b>8</b>	4.08	14.69	5.26	5.94	4.97	8.19	5.17	39.68
<b>6</b>	<b>9</b>	4.08	14.69	5.33	5.89	4.97	8.06	5.24	41.63