Application Note 001

OpenGo Reporting Parameters

Contact

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Changelog

Version	Date	Changes
2.2	20.04.2022	Revise units of COP and gait line parameters.
2.1	17.09.2021	Add comments to tables "Pressure Distribution Parameters" and "Spatial Parameters".
2.0	01.09.2021	Changed product name from SCIENCE to OpenGo.
1.2	20.03.2020	Add detailed explanation of vector parameters.
1.1	17.10.2019	Add spatial parameters. Add general notes on sample rates.
1.0	14.08.2019	Initial version

Contents

1 General Notes

Coordinates Various report parameters are given in x/y coordinates, where

- x is the posterior-anterior direction, and
- y is the lateral-medial direction.

Sample Rate The reporting parameters can be computed for any sample rate, however the accuracy of most parameters deteriorates with low sample rates. Note that the spatial parameters are only computed if the sample rate is at least 50 Hz (i.e. for 50 Hz and 100 Hz).

Data Channels Certain parameters require specific data channels, most notably:

- Parameters related to the pressure distribution require individual pressure values.
- All spatial parameters require angular rate and acceleration ("full" channel setup).

2 Gait Report

Table 1 — General Parameters

Parameter	Unit	Comment
Number of steps	1	Sum of number of left and right teps
Number of steps used for statistics	1	If set in the report settings, excludes first/last steps of walking sequences in order to exclude acceleration/deceleration

Table 2 — Gait Line Parameters

Parameter	Unit	Comment
Mean length/width of gait line	1[13]	Length/width (x direction/y direction) of the average gait line
Mean startpoint x/y of gait line	1[13]	Point where the average gait line starts (typically in heel area)
Mean endpoint x/y of gait line	1[13]	Point where the average gait line ends (typically in forefoot area)
Standard deviation x/y of gait line start-point	1[13]	Indicates how much the gait line start points spread around the mean start point
Standard deviation x/y of gait line end-point	1[13]	Indicates how much the gait line end points spread around the mean end point
Mean gait line (anterior-posterior)[1]	1[13]	x coordinates of the full representation of the average gait line as discretized points
Mean gait line (medial-lateral)[1]	1[13]	y coordinates of the full representation of the average gait line as discretized points
Stddev of average gait line	1[13]	Standard deviation of the gait line points in y direction, given for each x coordinate of the average gait line

[1] The *mean gait line* is determined by averaging the gait lines of individual steps, not by computing the gait line of the mean pressure distribution sequence. This way, the mean gait line can be computed in a consistent way based on COP values, even for those sensor setups which do not include individual pressure sensors, but only the COP. The averaging procedure divides the sensor insole in 200 sections along the x axis (anterior-posterior), and determines

the average COP value on the y axis (medial-lateral) for each section, separately. The length of the mean gait line is determined by the most posterior beginning and the most anterior ending of all gait lines. Numerically, the mean gait line is given as vector, and the number of elements in the vector is equal to $l_{\mathrm{GL}}/(l_{\mathrm{SI}}/200)+1$, where l_{SI} is the length of the sensor insole, and l_{GL} is the length of the mean gait line. The spacing of consecutive values of the mean gait line along the x axis (anterior-posterior) is equal to $l_{\mathrm{SI}}/200$. Consequently, the vector length is usually different for left and right. The same applies to the *standard deviation* of the mean gait line in medial-lateral direction, which is computed for each of the $l_{\mathrm{GL}}/(l_{\mathrm{SI}}/200)+1$ sections, separately.

Table 3 — Pressure Distribution Parameters

Parameter	**Unit**	**Comment**
Mean	N/cm2	Mean pressure[2] averaged over the entire measurement.
Maximum	N/cm2	Maximum pressure[2] occuring during the entire measurement.
Mean during stance phase	N/cm2	Mean pressure[2] averaged over all stance phases.
Maximum during stance phase	N/cm2	Maximum pressure[2] occuring during all stance phases.
During initial contact	N/cm2	Pressure[2] occuring in the middle of the loading response phase[3], averaged over all steps.
During mid stance	N/cm2	Pressure[2] occuring at the end of the mid stance phase[4], averaged over all steps.
During terminal stance	N/cm2	Pressure[2] occuring in the middle of combined terminal stance phase[5] and pre-swing phase[6], averaged over all steps.

[2] For each of the 16 pressure sensors.

The underlying gait phase durations are consistent with relevant literature describing typical gait patterns. Their duration, in terms of the percentage of the stance phase duration, is defined as follows (for consistency reasons, irrespective of the walking style):
[3] Loading response phase (starting with initial contact): 19.5%
[4] Mid stance phase: 30.5%
[5] Terminal stance phase: 30.5%
[6] Pre-swing phase (ending with toe-off): 19.5%

Table 4 — Ground Reaction Force Parameters

Parameter	**Unit**	**Comment**
Mean total force during stance phase	N	Mean value of the mean total force curve
Maximum total force during stance phase	N	Maximum of the the mean total force curve
Mean of all maxima of total force during all stance phases	N	This is not using the mean total force curve, but averages the maximum total force of all steps directly
Mean total force curve	N	Mean total force curve[7] as discretized data points, where the number of points depends on the average ground contact duration and the sample rate
Stddev of total force curve	N	Standard deviation of the total force curve data points over all steps, using the same duration scaling as for the mean total force curve

[7] The *mean total force curve* is the result of averaging the total force from initial contact to toe off over all detected steps. For averaging, the steps are scaled to a common duration, which is the mean stance duration t_{St}. Numerically, the mean total force curve is given as vector, and the number of elements in the vector is equal to $t_{\mathrm{St}}\cdot f_{\mathrm{S}}+2$ (including the leading and terminating zero value), where t_{St} is the mean stance duration, and f_{S} is the

sample rate (e.g. 100 Hz). The temporal spacing of consecutive values of the vector is equal to f_{S}^{-1}. The same applies to the *standard deviation* of the mean total force curve.

Table 5 — Temporal Parameters

Parameter	**Unit**	**Comment**
Mean gait cycle time	s	Time from the initial contact to the next initial contact of the same foot, averaged over all steps
Mean gait cadence	/min.	Mean number of strides per minute, computed using the mean gait cycle time
Mean double support time	s	Time during which both feet are on the ground, averaged over all steps
Mean fraction of double support	%	Mean double support time, relative to the mean gait cycle time
Mean double support time (left/right)[8]	s	Side-specific mean double support time, with the left mean double support time considering the time starting from the right foot's initial contact, until the left foot's toe off (and vice versa)
Mean step duration (left/right)[8]	s	Average time between consecutive initial contacts of left and right foot (and vice versa)
Mean stance duration	s	Time from initial contact to toe off (of the respective foot side), averaged over all steps
Stddev of stance duration	s	Standard deviation of the stance duration
Mean swing duration	s	Time from toe off to initial contact (of the respective foot side), averaged over all steps
Stddev of swing duration	s	Standard deviation of the swing duration
Mean fraction of stance phase	%	Mean stance duration, relative to the mean gait cycle time
Stddev of fraction of stance phase	%	Standard deviation of the mean fraction of stance phase
Mean fraction of swing phase	%	Mean swing duration, relative to the mean gait cycle time
Stddev of fraction of swing phase	%	Standard deviation of the mean fraction of swing phase

[8]Requires high-precision synchrony between left and right data, and is therefore only applicable to short measurements.

Table 6 — Weight Bearing Parameters

Parameter	Unit	Comment
Weight histogram values[9]	%	Histogram values representing the relative frequency of different total force ranges (bins), over the entire measurement
Weight histogram bins	kg	Upper border of the bins used for the weight histogram
Weight histogram values during stance phase[9]	%	Histogram values representing the relative frequency of different total force ranges (bins), limited to stance phases
Weight histogram bins during stance	kg	Upper border of the bins used for the weight histogram during stance phase

[9] The *weight histogram* uses a fixed bin width of 25 Newton to count the relative frequency of respective total force values. The number of bins is defined as 80, and loads exceeding $80 \cdot 25\,\mathrm{N} = 200\,\mathrm{N}$ are counted in the highest (80th) bin. Since the weight histogram is typically looked at with a notion of body weight and kilograms in mind, the bin boundaries are given in kg using a gravity rounded to 10 m/s^2.

Table 7 — Acceleration Parameters

Parameter	Unit	Comment
Mean acceleration (x/y/z) over gait cycle[10]	g	Result of averaging the acceleration curve over the gait cycle of all detected steps, where the gait cycles are scaled to a common duration, which is the average gait cycle time
Stddev of acceleration (x/y/z) over gait cycle	g	Standard deviation of the mean acceleration curve data points over all steps, using the same duration scaling as for the mean acceleration

[10] The *mean acceleration* over the gait cycle is the result of averaging the acceleration over the gait cycle of all detected steps. For averaging, the gait cycles are scaled to a common duration, which is the mean gait cycle time t_{GC}. Numerically, the mean acceleration curve is given as vector, and the number of elements in the vector is equal to $t_{\mathrm{GC}} \cdot f_{\mathrm{S}}$, where t_{GC} is the mean gait cycle time, and f_{S} is the sample rate (e.g. 100 Hz). The temporal spacing of consecutive values of the vector is equal to f_{S}^{-1}. The same applies to the *standard deviation* of the mean acceleration curve.

Table 8 — Spatial Parameters

Parameter	Unit	Comment
Mean stride length[11]	m	The stride length is defined as the displacement of the same foot in walking direction. This parameter is the mean over all detected steps. The mean is determined from left and right data, separately, and finally averaged over left and right.[1]
Walking distance[11]	m	The walking distance traveled over the entire measurement.
Mean walking speed[11]	m/s	The mean stride length divided by the mean gait cycle time. By not calculating this parameter from the walking distance and the measurement duration, non-walking periods will not affect (reduce) the mean walking speed.

[11] The spreadsheet export of the gait report contains per-step results also for the spatial parameters. In contrast to these per-step results, the computation of the overall parameters in Table 8 comprises a filtering stage, which turns slight zig-zag patterns into a straight walking direction, and improves the handling of sharp turns. Consequently, expect some numerical differences between the average of the per-step results, and the results of Table 8.

3 Balance Report

Table 9 — Center of Pressure (COP) Parameters

Parameter	Unit	Comment
Mean COP (AP/ML)	1[13]	Mean center of pressure (COP) in x direction/y direction[12]
Standard deviation of COP (AP/ML)	1[13]	Standard deviation of the COP in x direction/y direction[12]
Bounding box of COP (AP/ML)	1[13]	Length/width (x direction/y direction) of the box just containing all COP points, i.e. the range of COP points[12]
Mean COP velocity	1/s[13]	Mean velocity of the COP travelling across the sensor insole surface[12]
COP trace length	1[13]	Overall travel of the COP across the sensor insole surface[12]

[12] The balance report automatically detects single-leg-stance phases, and limits the computation of the parameter to these phases. If such phases are found for just one leg, the other leg is not considered. If single-leg-stance phases are not found at all, the parameter is computed over the entire measurement.

[13] The COP and gait line parameters are given in a dimensionless coordinate system, which is normalized by the sensor insole length and width. The origin of this coordinate system is located in the sensor insole center. The value ranges of the x (anterior to posterior) and y (lateral to medial) dimensions are: x in [-0.5, 0.5], y in [-0.574; 0.426].