

24 Result Class Variables

Variables and their definitions for the 3 results classes are presented here. Detailed mathematical explanations and associated equations are available in the Methods Manuscript.

24.1 Lead Morphology Class (**LeadMorphology.m**)

[lead] refers to any of the 16 leads (L1, L2, L3, avR, avL, avF, V1-V6, X, Y, Z, VM)

Variable	Description	Units
[lead]_r_wave	Magnitude of R wave on median beat of [lead]	mV
[lead]_r_wave_loc	Timing of R wave peak (after QRS onset) in [lead]	ms
[lead]_s_wave	Magnitude of S wave on median beat of [lead]	mV
[lead]_s_wave_loc	Timing of S wave peak (after QRS onset) in [lead]	ms
[lead]_rs_wave	Magnitude of entire QRS complex = [lead]_r_wave + abs([lead]_s_wave	mV
[lead]_rs_ratio	Ratio of R wave to magnitude of entire QRS complex = [lead]_r_wave / [lead]_rs_wave	—
[lead]_sr_ratio	Ratio of S wave to magnitude of entire QRS complex = [lead]_s_wave / [lead]_rs_wave	—
[lead]_t_max	Maximum magnitude of T wave in [lead]	mV
[lead]_t_max_loc	Timing of T wave maximum (after QRS onset) in [lead]	ms
[lead]_qrs_area	Area of [lead] median beat QRS complex	mV·ms
[lead]_t_area	Area of [lead] median beat T wave	mV·ms
[lead]_qrst_area	Area of [lead] median beat full QRST complex	mV·ms
[lead]_jpt	Magnitude of [lead] at the J point (Q_{off})	mV
[lead]_jpt60	Magnitude of [lead] at the J point (Q_{off}) + 60 ms	mV
cornell_lv_h_mv	Cornell LVH = $V3_s_wave + avL_r_wave$	mV
sokolow_lv_h_mv	Sokolow-Lyon LVH = $V1_s_wave + \max(V5_r_wave, V6_r_wave)$	mV
qrs_frontal_axis	Frontal plane QRS axis	deg

24.2 VCG Morphology Class (**VCG_Morphology.m**)

Variable	Description	Units
TCRT	Total Cosine R to T (range 0 - 1)	–
TCRT_angle	Angle from TCRT = $\text{acos}(\text{TCRT})$	deg
qrsloop_residual	SVD variance from fitting QRS loop to a plane (0 = perfect fit) = qrs_S3^2	–
qrsloop_rmse	RMSE for fit of QRS loop to best fit plane (0 = perfect fit)	mV
qrsloop_roundness	QRS loop roundness. 1 = perfect circle, larger values are increasingly elliptical = $\text{qrs_S1}/\text{qrs_S2}$	–
qrsloop_area	Area of QRS loop	mV
qrsloop_perimeter	Length of QRS loop projected into best fit plane	mV ²
tloop_residual	SVD variance from fitting T loop to a plane (0 = perfect fit) = t_S3^2	–
tloop_rmse	RMSE for fit of T loop to best fit plane (0 = perfect fit)	mV
tloop_roundness	T loop roundness. 1 = perfect circle, larger values are increasingly elliptical = $\text{t_S1}/\text{t_S2}$	–
tloop_area	Area of T loop	mV
tloop_perimeter	Length of T loop projected into best fit plane	mV ²
qrs_loop_normal	Unit vector normal to best fit QRS loop plane	–
t_loop_normal	Unit vector normal to best fit T loop plane	–
qrst_dihedral_ang	Dihedral angle between best fit QRS loop and T loop planes	deg
qrs_loop_plane_az	Azimuth angle for unit vector normal to best fit QRS loop plane	deg
qrs_loop_plane_el	Elevation angle for unit vector normal to best fit QRS loop plane	deg
t_loop_plane_az	Azimuth angle for unit vector normal to best fit T loop plane	deg
t_loop_plane_el	Elevation angle for unit vector normal to best fit T loop plane	deg
qrs_S1	1st singular value of QRS loop	–
qrs_S2	2nd singular value of QRS loop	–
qrs_S3	3rd singular value of QRS loop	–
t_S1	1st singular value of T loop	–
t_S2	2nd singular value of T loop	–
t_S3	3rd singular value of T loop	–
qrs_var_s1_total	% of total variance made up by 1st QRS singular value	%
qrs_var_s2_total	% of total variance made up by 2nd QRS singular value	%
qrs_var_s3_total	% of total variance made up by 3rd QRS singular value	%
t_var_s1_total	% of total variance made up by 1st T singular value	%
t_var_s2_total	% of total variance made up by 2nd T singular value	%
t_var_s3_total	% of total variance made up by 3rd T singular value	%
TMD	T wave mechanical dispersion	deg
TWR_abs	Absolute T wave residuum	mV ²
TWR_rel	Relative T wave residuum	%
xy_qrs_loop_dir	Direction of rotation of QRS loop in XY plane ('CW', 'CCW', or 'Indeterminate')	–
xy_qrs_signed_area	Signed area of QRS loop in XY plane	mV ²
xz_qrs_loop_dir	Direction of rotation of QRS loop in XZ plane ('CW', 'CCW', or 'Indeterminate')	–
xz_qrs_signed_area	Signed area of QRS loop in XZ plane	mV ²
zy_qrs_loop_dir	Direction of rotation of QRS loop in ZY plane ('CW', 'CCW', or 'Indeterminate')	–
zy_qrs_signed_area	Signed area of QRS loop in ZY plane	mV ²
best_qrs_loop_dir	Direction of rotation of QRS loop in best fit plane ('CW', 'CCW', or 'Indeterminate')	–
best_qrs_signed_area	Signed area of QRS loop in best fit plane (absolute value should approximate <code>qrsloop_area</code>)	mV ²

24.3 VCG Calculation Class (**VCG_Calc.m**)

Variable	Description	Units
qrs_int	QRS duration	ms
qt_int	QT interval	ms
svg_x	X component of SVG = $XQ_area + XT_area$	mV·ms
svg_y	Y component of SVG = $YQ_area + YT_area$	mV·ms
svg_z	Z component of SVG = $ZQ_area + ZT_area$	mV·ms
sai_x	Area under absolute value of the median X QRST complex	mV·ms
sai_y	Area under absolute value of the median Y QRST complex	mV·ms
sai_z	Area under absolute value of the median Z QRST complex	mV·ms
sai_qrst	SAI QRST = $sai_x + sai_y + sai_z$	mV·ms
sai_vm	Area under median VM QRST complex (always positive)	mV·ms
q_peak_mag	Magnitude of peak QRS vector	mV
q_peak_az	Azimuth of peak QRS vector	deg
q_peak_el	Elevation of peak QRS vector	deg
t_peak_mag	Magnitude of peak T wave vector	mV
t_peak_az	Azimuth of peak T wave vector	deg
t_peak_el	Elevation of peak T wave vector	deg
svg_peak_mag	Magnitude of the sum of peak QRS and peak T vectors (“peak SVG”)	mV
svg_peak_az	Azimuth of the “peak SVG” vector	deg
svg_peak_el	Elevation of the “peak SVG” vector	deg
q_area_mag	Magnitude of QRS area vector ($[XQ_area, YQ_area, ZQ_area]$)	mV·ms
q_area_az	Azimuth of QRS area vector	deg
q_area_el	Elevation of QRS area vector	deg
t_area_mag	Magnitude of T-wave area vector $[XT_area, YT_area, ZT_area]$	mV·ms
t_area_az	Azimuth of T-wave area vector	deg
t_area_el	Elevation of T-wave area vector	deg
svg_area_mag	Magnitude of the SVG vector $[svg_x, svg_z, svg_z]$	mV·ms
svg_area_az	Azimuth of the SVG vector	deg
svg_area_el	Elevation of the SVG vector	deg
qrst_angle_area	Area (mean) QRST angle: 3D angle between area QRS and area T wave vectors	deg
qrst_angle_peak	Peak QRST angle: 3D angle between peak QRS and peak T wave vectors	deg
qrst_angle_peak_frontal	Projection of area QRST angle into frontal plane	deg
qrst_angle_area_frontal	Projection of peak QRST angle into frontal plane	deg
XQ_area	Area under median X QRS complex	mV·ms
YQ_area	Area under median Y QRS complex	mV·ms
ZQ_area	Area under median Z QRS complex	mV·ms
XT_area	Area under median X T wave	mV·ms
YT_area	Area under median Y T wave	mV·ms
ZT_area	Area under median Z T wave	mV·ms
VMQ_area	Area under median VM QRS complex	mV·ms
VMT_area	Area under median VM T wave	mV·ms

Variable	Description	Units
XQ_peak	Value of median X QRS complex at time of maximum distance from origin	mV
YQ_peak	Value of median Y QRS complex at time of maximum distance from origin	mV
ZQ_peak	Value of median Z QRS complex at time of maximum distance from origin	mV
XT_peak	Value of median X T wave at time of maximum distance from origin	mV
YT_peak	Value of median Y T wave at time of maximum distance from origin	mV
ZT_peak	Value of median Z T wave at time of maximum distance from origin	mV
speed_max	Maximum speed across the entire VCG loop	mV/ms
speed_min	Minimum speed across the entire VCG loop	mV/ms
speed_med	Median speed across the entire VCG loop	mV/ms
time_speed_max	Time after QRS onset of maximum VCG speed	ms
time_speed_min	Time after QRS onset of minimum VCG speed	ms
speed_qrs_max	Maximum speed across the QRS VCG loop	mV/ms
speed_qrs_min	Minimum speed across the QRS VCG loop	mV/ms
speed_qrs_med	Median speed across the QRS VCG loop	mV/ms
time_speed_qrs_max	Time after QRS onset of maximum QRS speed	ms
time_speed_qrs_min	Time after QRS onset of minimum QRS speed	ms
speed_t_max	Maximum speed across the T wave loop	mV/ms
speed_t_min	Minimum speed across the T wave loop	mV/ms
speed_t_med	Median speed across the T wave loop	mV/ms
time_speed_t_max	Time after QRS onset of maximum T-wave speed	ms
time_speed_t_min	Time after QRS onset of minimum T-wave speed	ms
sti_qrst	Speed-time integral for QRST complex	mV
sti_qrs	Speed-time integral for QRS complex	mV
sti_t	Speed-time integral for T Wave	mV
qrst_distance_area	Distance between the area QRS and area T vectors	mV
qrst_distance_peak	Distance between the area QRS and area T vectors	mV
vcg_length_qrs	Length of QRS VCG loop	mV
vcg_length_t	Length of T wave VCG loop	mV
vcg_length_qrst	Length of QRST VCG loop = $\text{vcg_length_qrs} + \text{vcg_length_t}$	mV
vm_tpeak_time	Time after QRS onset of peak of median VM Twave	ms
vm_tpeak_tend_abs_diff	Time difference between T wave peak and T wave end in median VM lead	ms
vm_tpeak_tend_ratio	Ratio between time of T wave peak and time of T wave end in median VM lead	–

24.4 Other Variables

Variable	Description	Units/Format
filename	ECG filename	—
version	BRAVEHEART version	—
date	Date single ECG data or batch data exported	MM/DD/YYYY
time	Date single ECG data or batch data exported	HH:mm
source	ECG file format string	—
freq	ECG sampling frequency	Hz
num_samples	number of samples in ECG file	—
num_beats	number of QRST complexes processed to make median beat	—
initial_num_beats	number of QRST complexes initially detected	—
num_pvcs_removed	number of beats removed due to PVC detection	—
num_outliers_removed	number of beats removed due to outlier detection	—
num_bad_removed	number of beats removed due to being incomplete (at very start/end of tracing)	—
hr	heart rate	bpm
cross_corr	Minimum normalized cross correlation for X, Y, and Z leads	—
noise_hf	Estimation of high-frequency noise in raw signal (minimum estimated SNR for all leads)	dB
noise_lf	Estimation of low-frequency noise/wander in raw signal by measuring variance of wander	mV
qual_prob	Probability of ECG being "good" quality (range 0-1)	—
missing_lead	Binary variable for a lead missing from the ECG	—
Q	Location in samples of Q_{on} for individual beats included in the median	Samples
QRS	Location in samples of R peaks for individual beats included in the median	Samples
S	Location in samples of Q_{off} for individual beats included in the median	Samples
Tend	Location in samples of T_{off} for individual beats included in the median	Samples
QRS_rem_pvc	Location in samples of R peaks for beats removed by PVC detection/removal	Samples
QRS_rem_outlier	Location in samples of R peaks for beats removed by outlier detection/removal	Samples
QRS_rem_manual	Location in samples of R peaks for beats removed manually	Samples
QRS_rem_bad	Location in samples of R peaks for beats removed due to being incomplete or overlapping	Samples
qrs_median	Median value for QRS duration for all individual beats included in the median	Samples
qrs_min	Minimum value for QRS duration for all individual beats included in the median	Samples
qrs_max	Maximum value for QRS duration for all individual beats included in the median	Samples
qrs_iqr	Interquartile range for QRS duration for all individual beats included in the median	Samples
jt_median	Median value for JT interval for all individual beats included in the median	Samples
jt_min	Minimum value for JT interval for all individual beats included in the median	Samples
jt_max	Maximum value for JT interval for all individual beats included in the median	Samples
jt_iqr	Interquartile range for JT interval for all individual beats included in the median	Samples
qt_median	Median value for QT interval for all individual beats included in the median	Samples
qt_min	Minimum value for QT interval for all individual beats included in the median	Samples
qt_max	Maximum value for QT interval for all individual beats included in the median	Samples
qt_iqr	Interquartile range for QT interval for all individual beats included in the median	Samples
RR_n	RR intervals only for beats included in median beat	ms
RR_pct_n	Percent change in subsequent RR intervals only for beats included in median beat	%
RR_sd_n	Successive differences in RR intervals only for beats included in median beat	ms
RR	RR intervals for all R peaks regardless of if they were removed	ms
RR_pct	Percent change in subsequent RR intervals regardless of if they were removed	%
RR_sd	Successive differences in RR intervals regardless of if they were removed	ms
SDNN	Standard deviation of RR intervals only for beats included in median beat	ms
SDRR	Standard deviation of RR intervals regardless of if they were removed	ms
RMSSD_n	Root mean square of successive differences only for beats included in median beat	ms
RMSSD_all	Root mean square of successive differences regardless of if they were removed	ms
pacing_detected	Flag for if pacing was detected (1) or not (0) using either pacemaker detection method	—
num_paced_leads	Number of leads in which pacing was detected if using CWT spike removal method	—