

Exhaustive Gait Plots

The following MATLAB Live Script includes the exhaustive individual plots for a total of 49 experiments performed on the orange 4-limbed robot on the black mat. Each experimental gait test is accompanied by the following individual plots: (1) experimental gait trajectory with arrows representing the global robot orientation, (2) twist components w.r.t. both time and global robot orientation, (3) instantaneous center of rotation, and (4) radius of curvature over time.

Warning: Name is nonexistent or not a directory:

C:\Users\clfreeman7\Documents\GitHub\IROS2022\demos\data\visualtracking\data\visualtracking

Extract and define parameters for GaitTest() objects.

From 20220707 Experiments:

Gait B-120 [heavy - not following (restting) - left/up]

Gait E-120 [heavy - not following - left/up]

Gait E-60 [heavy - not following - left/up]

Gait E*-60 [heavy - not following - right/up] Caution! Not real E gait! Limb A not actuating

From 20220819 Experiments:

Gait B-120 [light sheath - not following (restting) - right/up]

From 20220829 Experiments:

Gait B* Follow (Left) [light sheath - following - left] Caution! Not real B gait! Limb A not actuating

Gait B* Follow (Right) [light sheath - following - right] Caution! Not real B gait! Limb A not actuating

Gait E Left (sheath on) [light sheath - not following - left]

Gait E Right (sheath on) [no sheath - not following - right]

Gait E Left (sheath off) [no sheath - not following - left]

Gait E* Right (sheath off) [no sheath - not following - right] Caution! Not real E gait! Limb B not actuating

From 20220901 Experiments:

Gait E Left (sheath off) [no sheath - not following - left (flipped)]

Gait B Follow (Left) Trial 1 [light sheath - following - left]

Gait B Follow (Left) Trial 2 [light sheath - following - left (flipped)]

Gait B Left (Sheath on) Trial 1 [light sheath - not following - left]

Gait B Left (Sheath on) Trial 2 [light sheath - not following - left (flipped)]

From 20220908 Experiments:

Gait B Right (sheath on) [sheath - not following - right] (not consistent / semi-following)

Gait B Right Follow (sheath off) Trial 1 [no sheath - following - right]

Gait B Right Follow (sheath off) Trial 2 [no sheath - following - right]
Gait B Left Follow (sheath off) Trial 1 [no sheath - following - left]
Gait B Left Follow (sheath off) Trial 2 [no sheath - following - left]
Gait B Right (sheath off) Trial 1 [no sheath - not following - right] (not consistent / semi-following)
Gait B Right (sheath off) Trial 2 [no sheath - not following - right] (not consistent / semi-following)
Gait B Left (sheath off) Trial 1 [no sheath - not following - left] (not consistent / semi-following)
Gait B Left (sheath off) Trial 2 [no sheath - not following - left] (not consistent / semi-following)
Gait B Right Follow (sheath on) [sheath - following - right]
Gait E Right (sheath off) Trial 1 [no sheath - not following - right] (not consistent / semi-following)
Gait E Right (sheath off) Trial 2 [no sheath - not following - right] (not consistent / semi-following)
Gait E Left (sheath off) Trial 1 [no sheath - not following - left] (not consistent / semi-following)
Gait E Left (sheath off) Trial 2 [no sheath - not following - left] (not consistent / semi-following)

From 20220928 Experiments:

Gait B Left AWG 32 Trial 1 [AWG 32 sheath - not following - left]
Gait B Left AWG 32 Trial 2 [AWG 32 sheath - not following - left]
Gait B Right AWG 32 Trial 1 [AWG 32 sheath - not following - right]
Gait B Right AWG 32 Trial 2 [AWG 32 sheath - not following - right]
Gait B Right AWG 32 Trial 1 [AWG 32 slip ring - not following - right]
Gait B Right AWG 32 Trial 2 [AWG 32 slip ring - not following - right]

From 20221018 Experiments:

Gait F Left AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - left]
Gait F Left AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - left]
Gait G Left AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - left]
Gait G Left AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - left]

From 20221102 Experiments:

Gait G Right AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - right]
Gait G Right AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - right]
Gait B Left AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - left]
Gait B Right AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - right]
Gait H Left AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - left]
Gait H Left AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - left]
Gait H Right AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - right]

Gait H Right AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - right]

Gait F Right AWG 32 Slip ring Trial 1 [AWG 32 slip ring - not following - right]

Gait F Right AWG 32 Slip ring Trial 2 [AWG 32 slip ring - not following - right]

Build Experiment Matrix

sorted_exps = 49x7 table

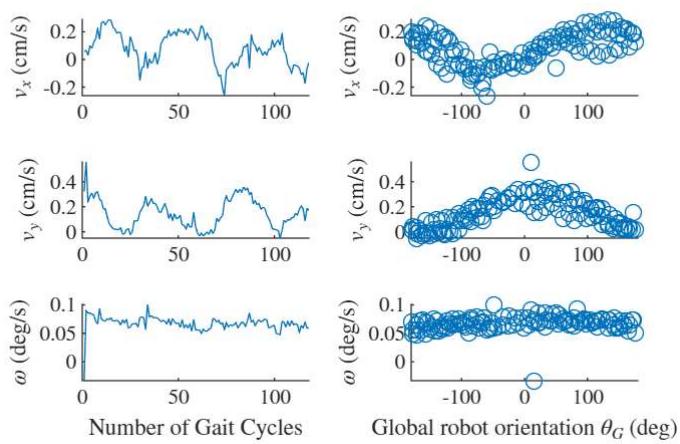
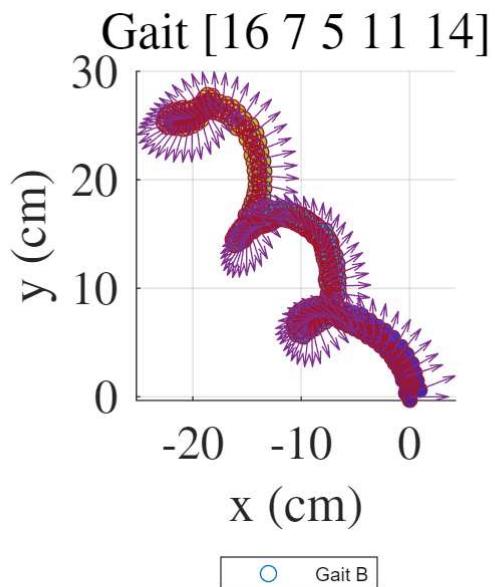
	Experiment	Gait	#Cycles	Tether	Protocol	Placement
1	31	'B'	'60'	'32'	'NF'	'L'
2	32	'B'	'60'	'32'	'NF'	'L'
3	33	'B'	'60'	'32'	'NF'	'R'
4	34	'B'	'60'	'32'	'NF'	'R'
5	42	'B'	'60'	'32SR'	'NF'	'L'
6	43	'B'	'60'	'32SR'	'NF'	'R'
7	35	'B'	'60'	'32SR1'	'NF'	'R'
8	1	'B'	'120'	'H'	'NF'	'L'
9	20	'B'	'60'	'NS'	'F'	'L'
10	21	'B'	'60'	'NS'	'F'	'L'
11	18	'B'	'60'	'NS'	'F'	'R'
12	19	'B'	'60'	'NS'	'F'	'R'
13	24	'B'	'60'	'NS'	'NF'	'L'
14	25	'B'	'60'	'NS'	'NF'	'L'
⋮						

Analyze the experiment data:

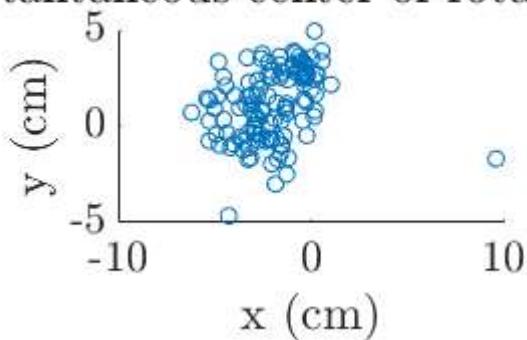
1. Rotate the data w.r.t. the initial global orientation.
2. Instantiate GaitTest() objects for each experimental trial.
3. Calculate twists for each gait experiment.

Make exhaustive plots for each experiment.

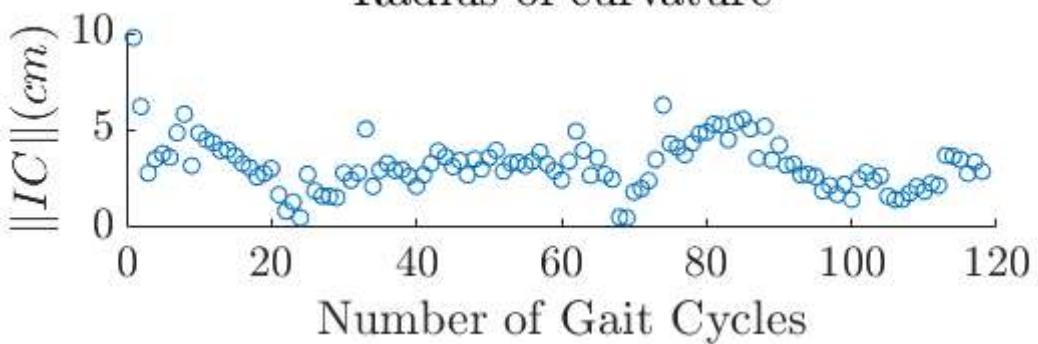
Experiment 1 : 120 cycles of Gait B with heavy sheath tether (left , not following), trial 1



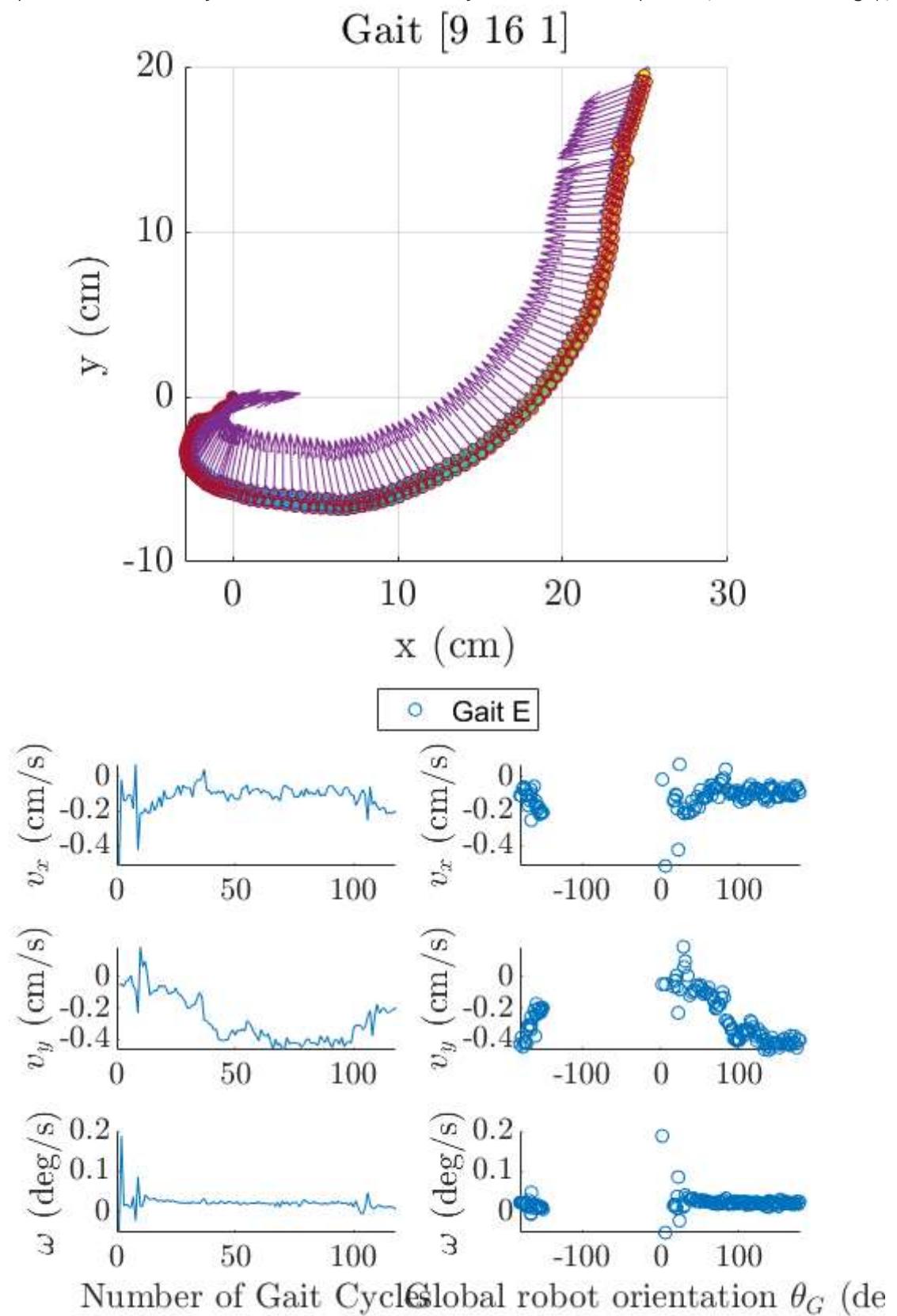
Instantaneous center of rotation IC



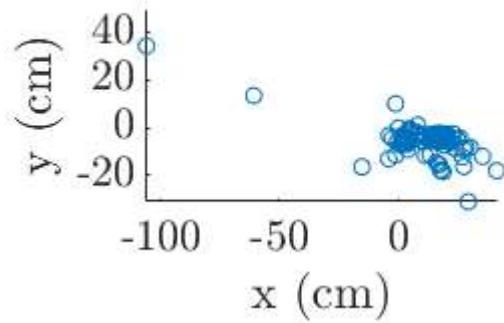
Radius of curvature



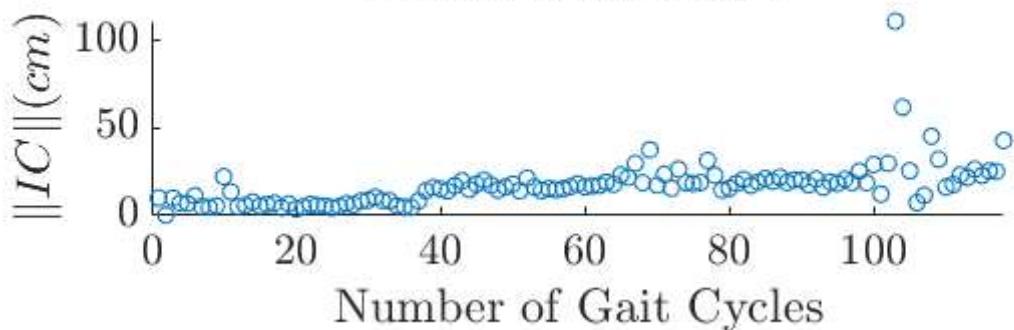
Experiment 2 : 120 cycles of Gait E with heavy sheath tether (left , not following), trial 1



Instantaneous center of rotation IC

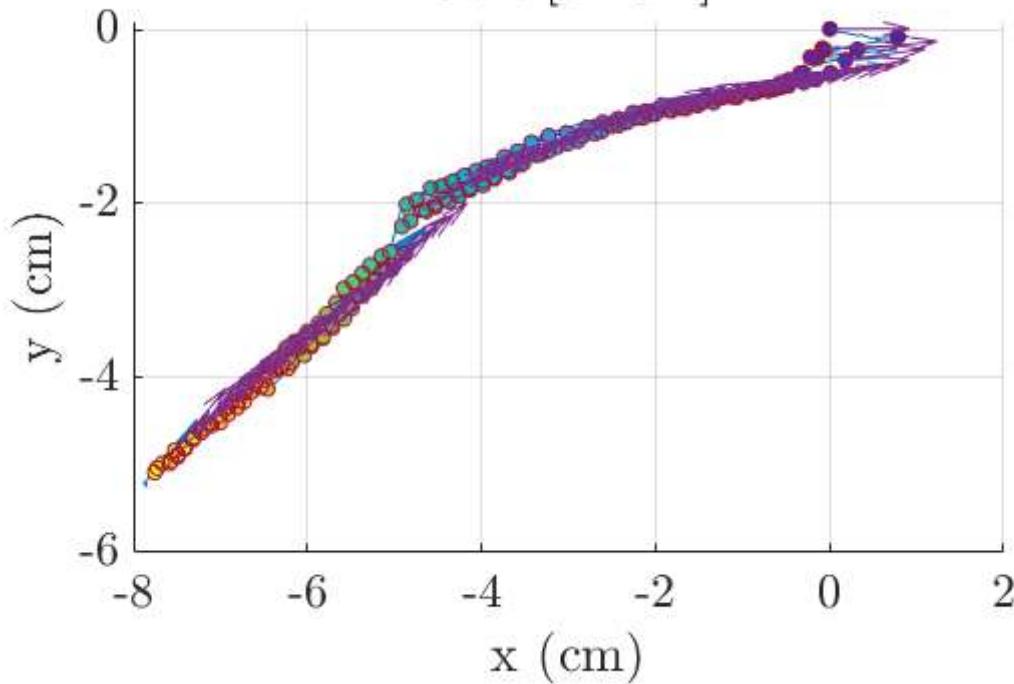


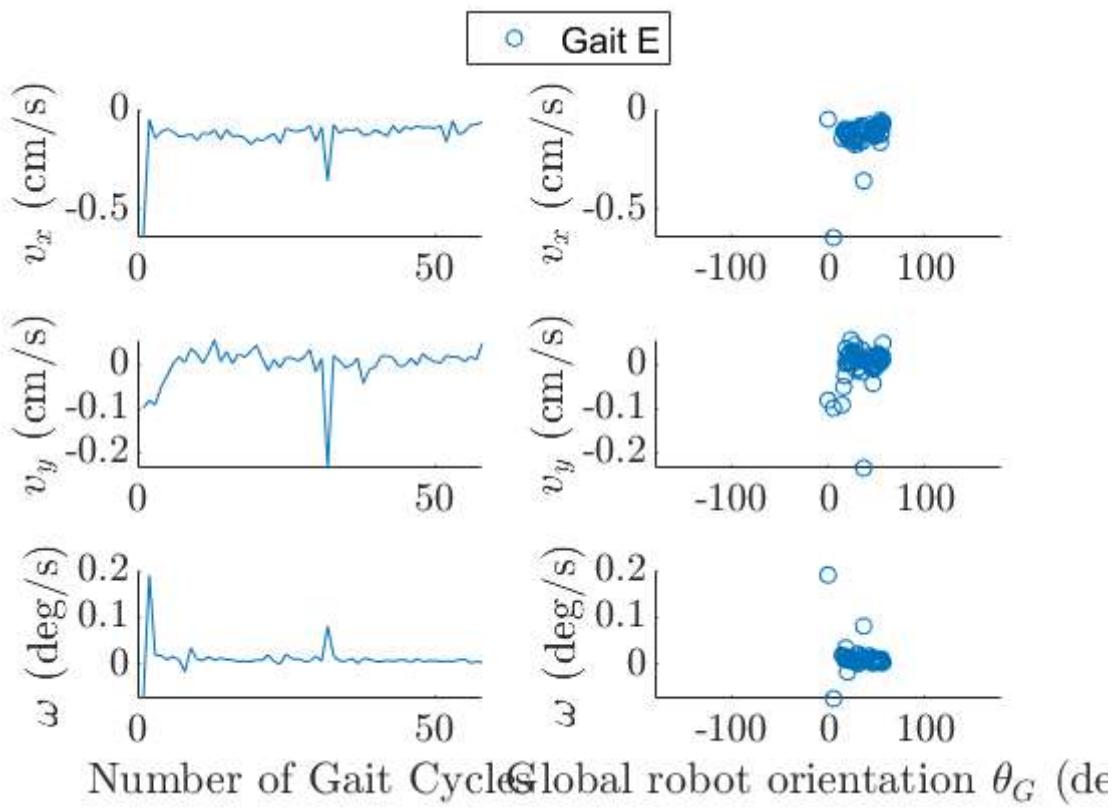
Radius of curvature



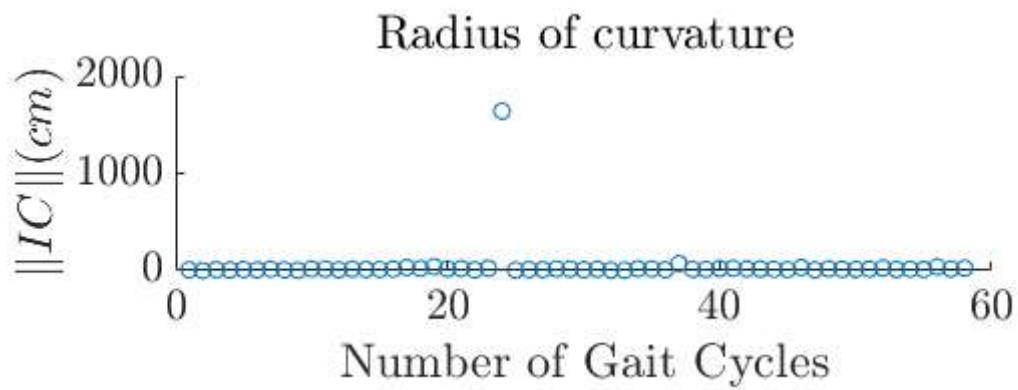
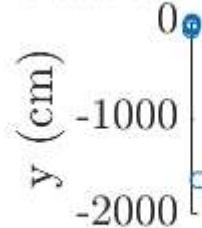
Experiment 3 : 60 cycles of Gait E with heavy sheath tether (left , not following), trial 1

Gait [9 16 1]

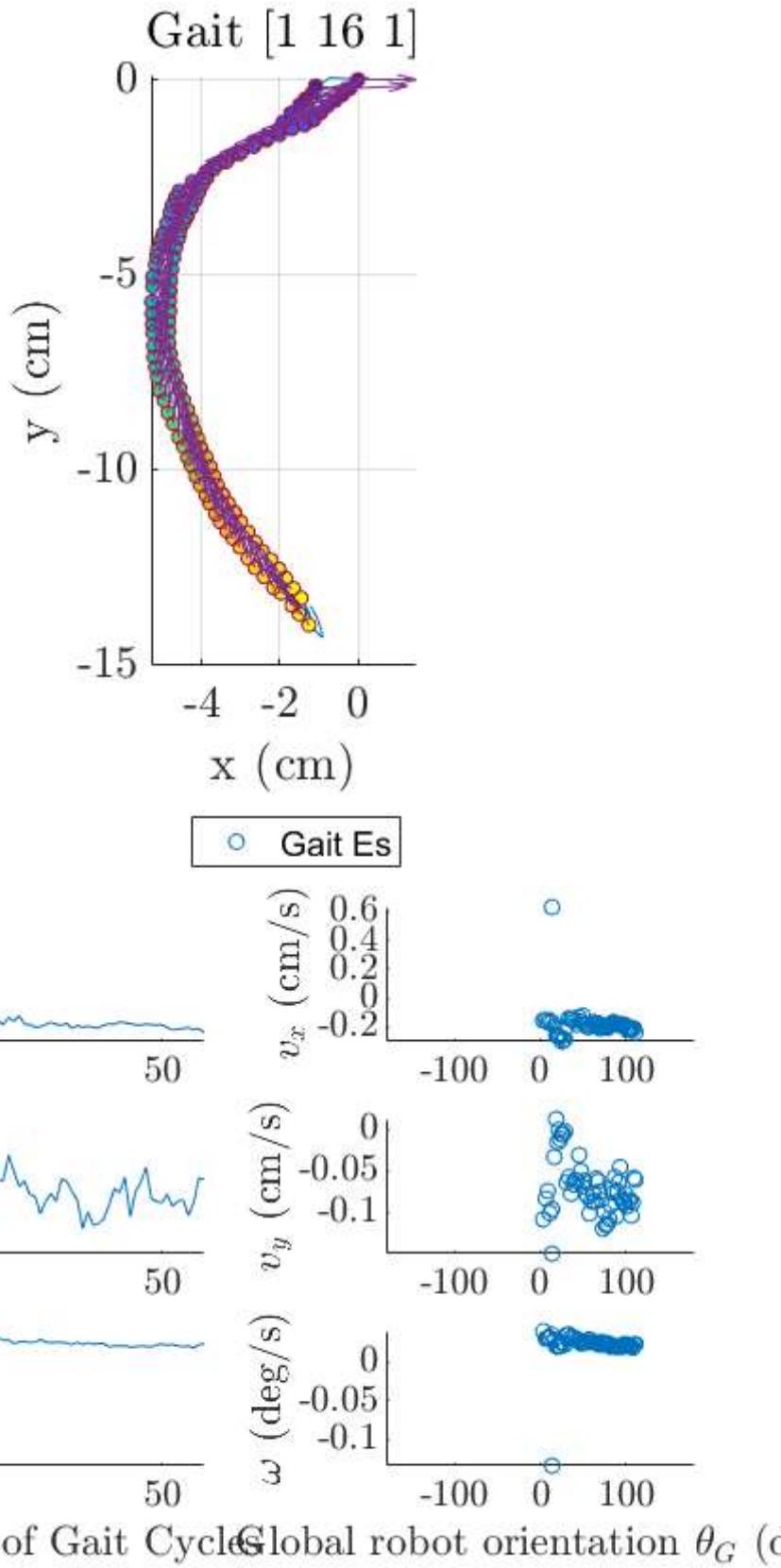




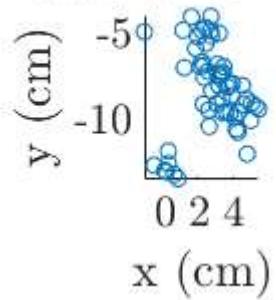
Instantaneous center of rotation IC



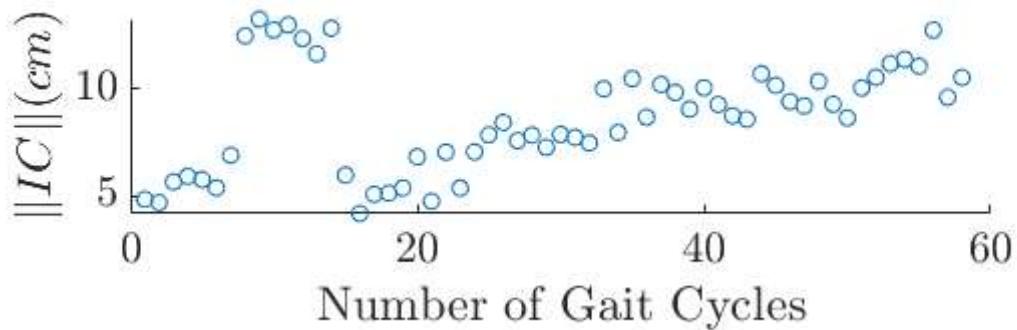
Experiment 4 : 60 cycles of Gait Es with heavy sheath tether (right , not following), trial 1



Instantaneous center of rotation IC

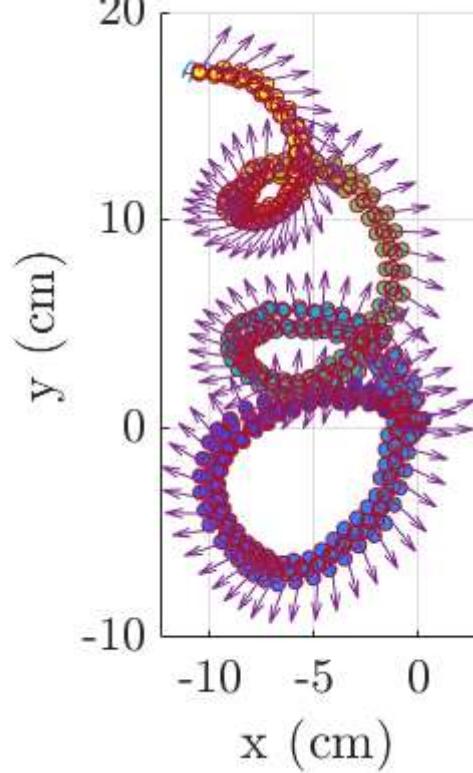


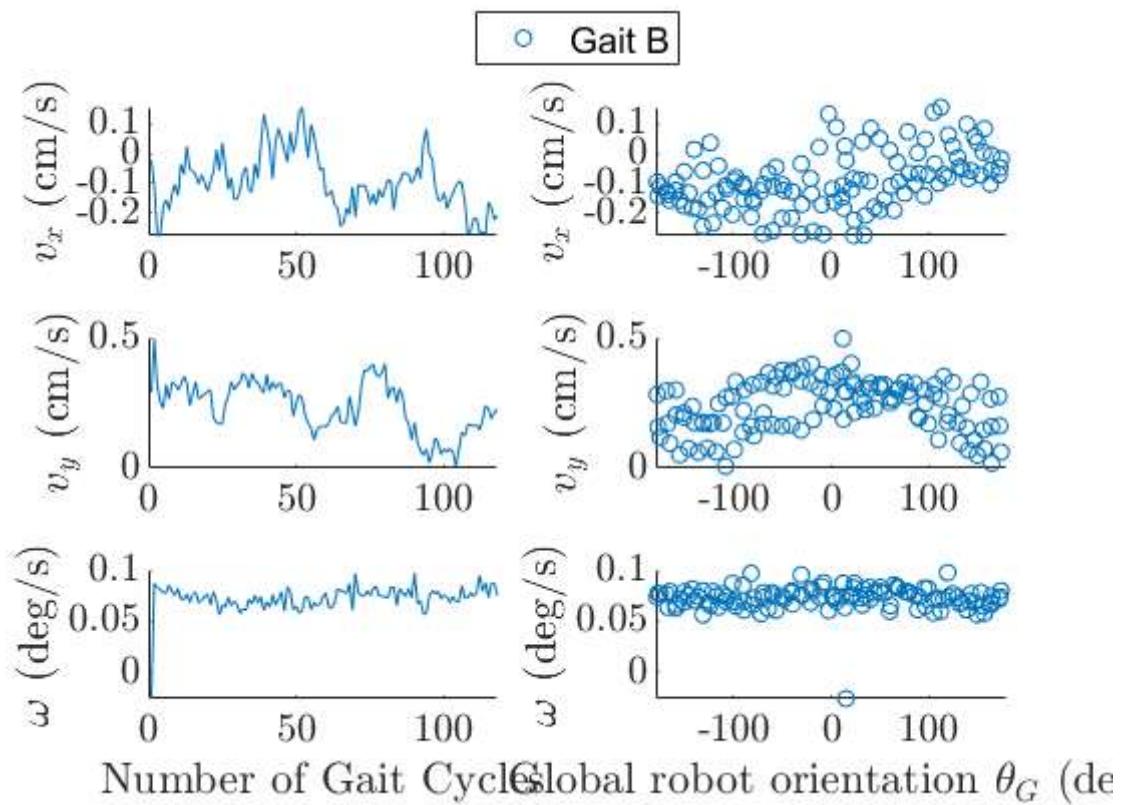
Radius of curvature



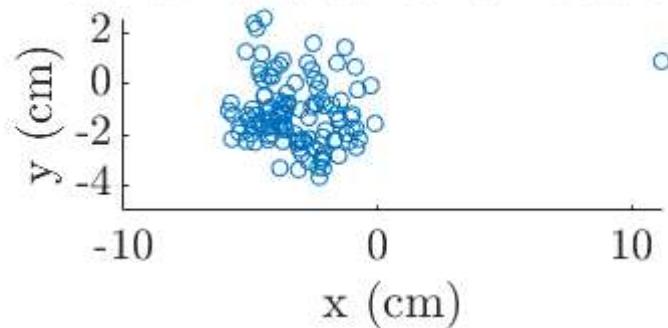
Experiment 5 : 120 cycles of Gait B with light sheath tether (right , not following), trial 1

Gait [16 7 5 11 14]

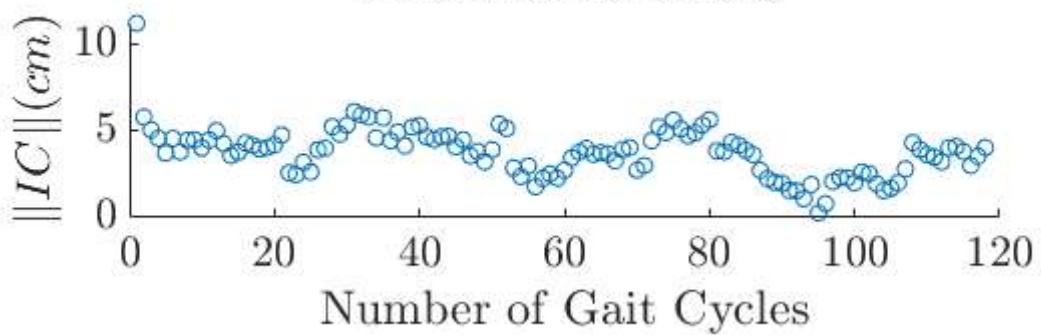




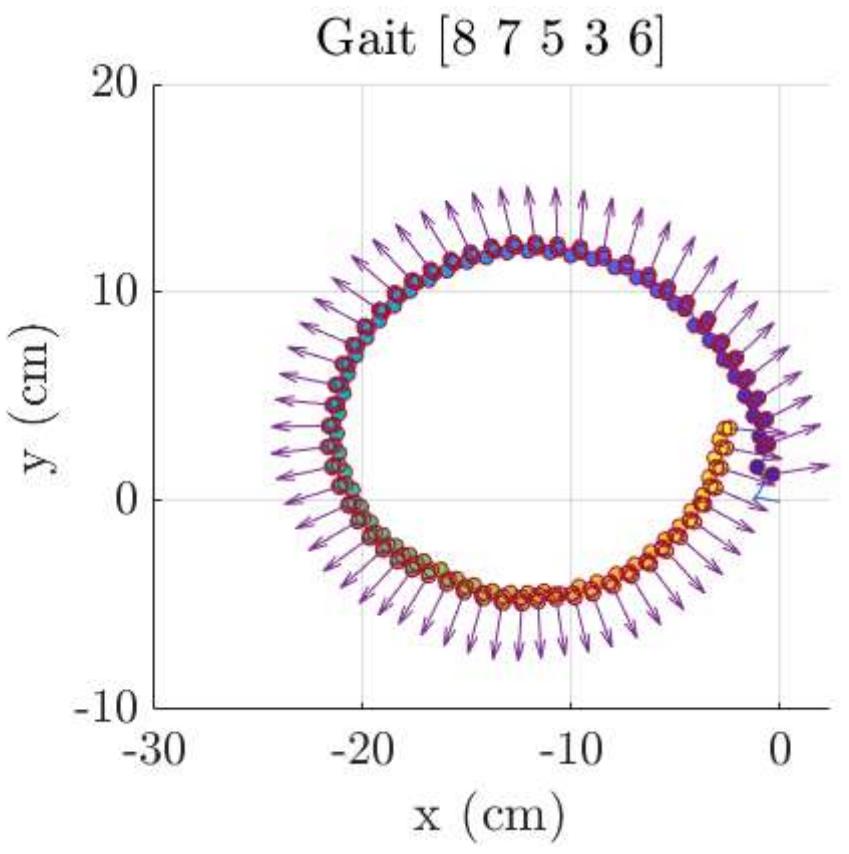
Instantaneous center of rotation IC



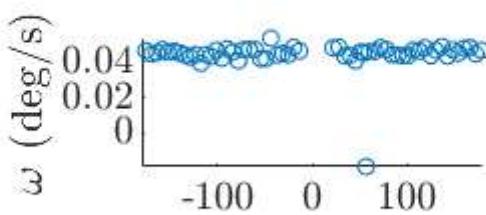
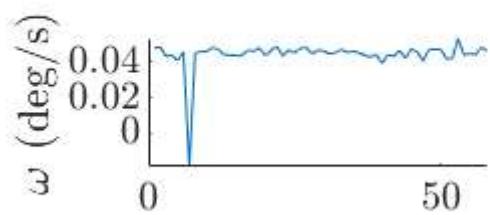
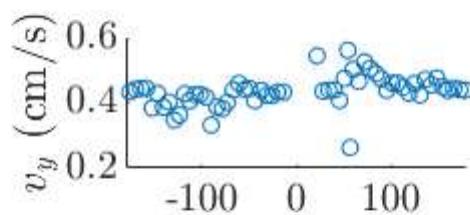
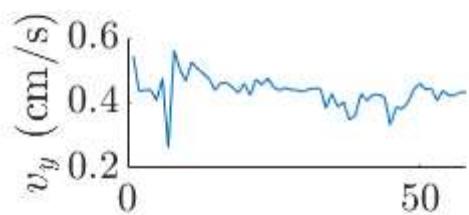
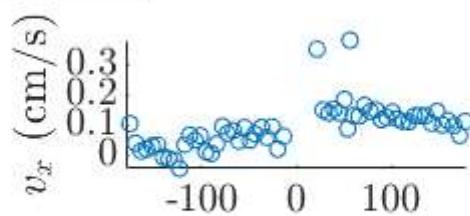
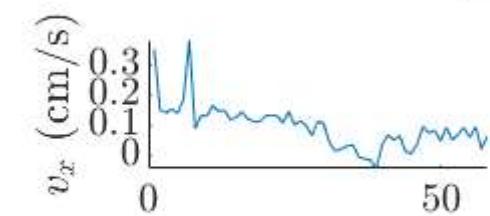
Radius of curvature



Experiment 6 : 60 cycles of Gait Bs with light sheath tether (left , following), trial 1

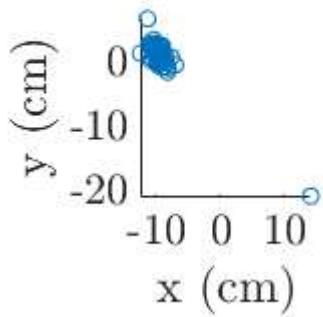


○ Gait Bs

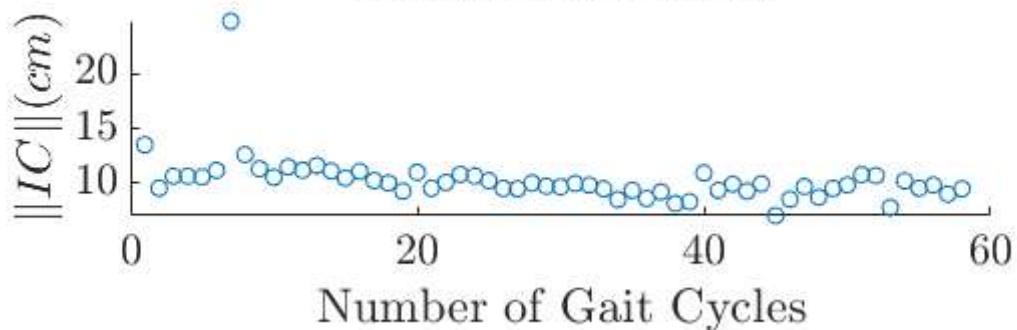


Number of Gait Cycles Global robot orientation θ_G (deg)

Instantaneous center of rotation IC

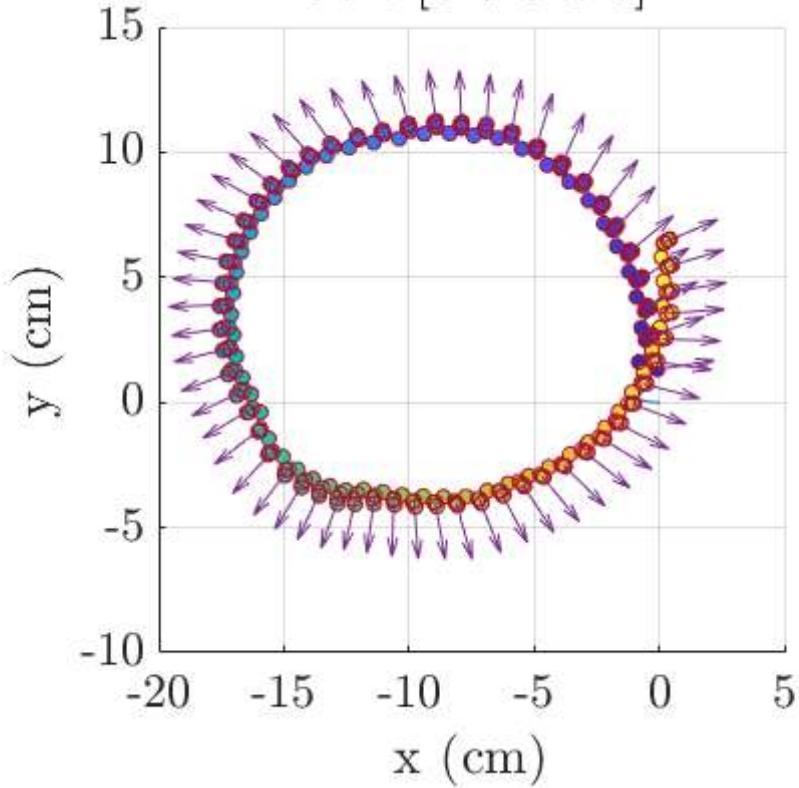


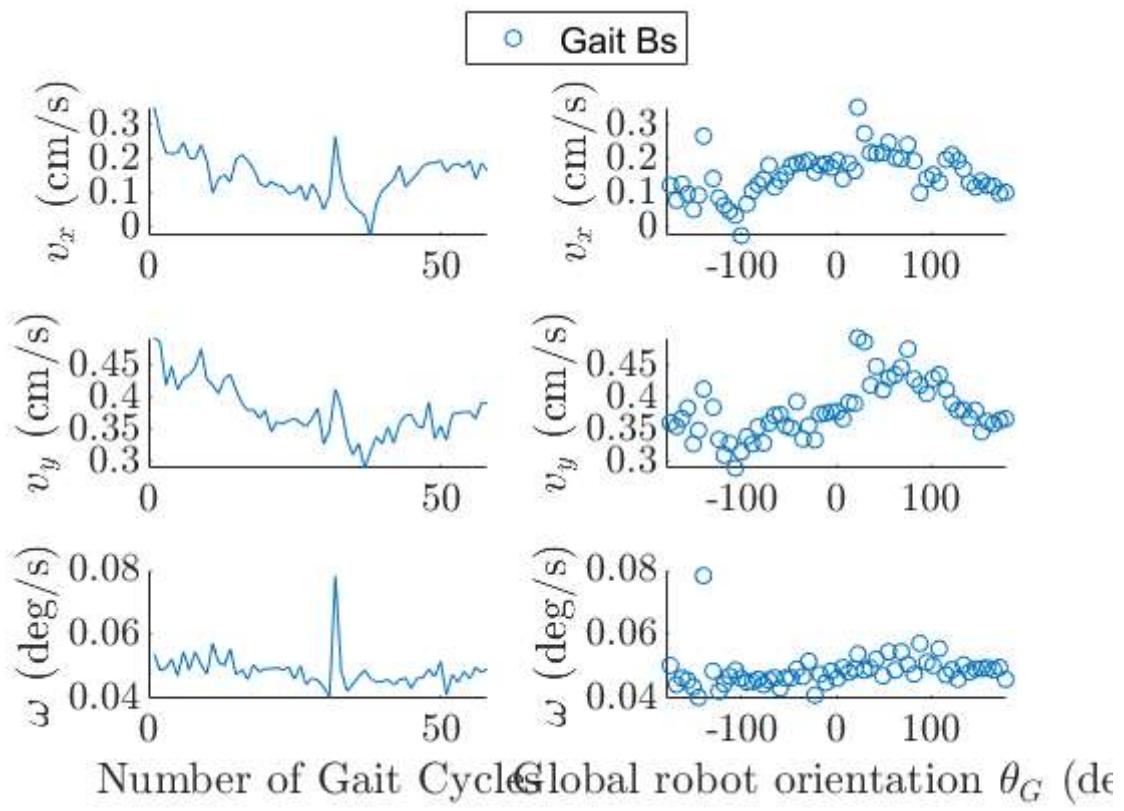
Radius of curvature



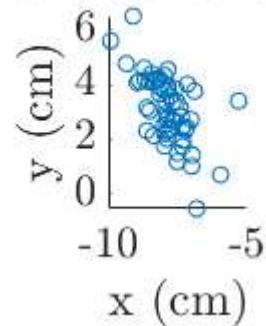
Experiment 7 : 60 cycles of Gait Bs with light sheath tether (right , following), trial 1

Gait [8 7 5 3 6]

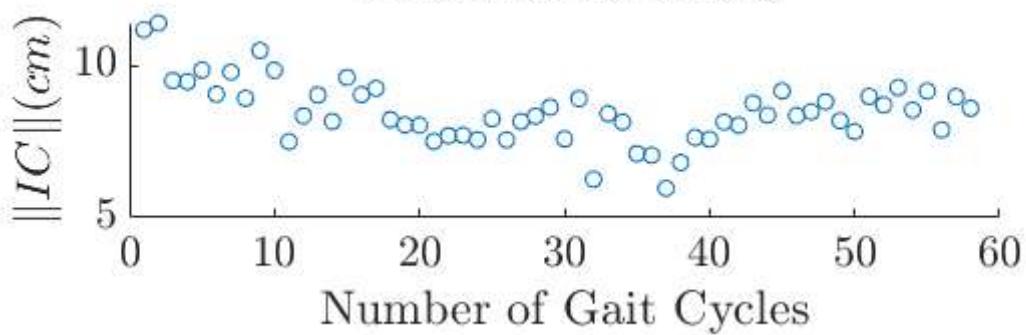




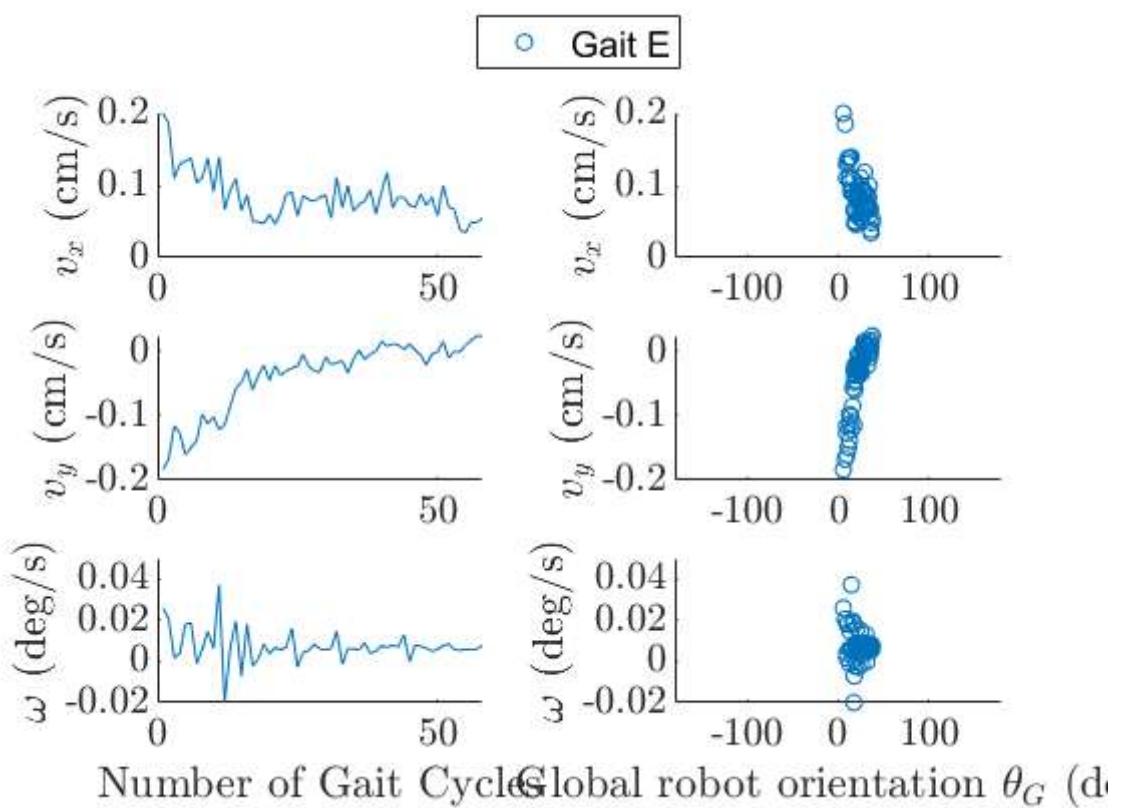
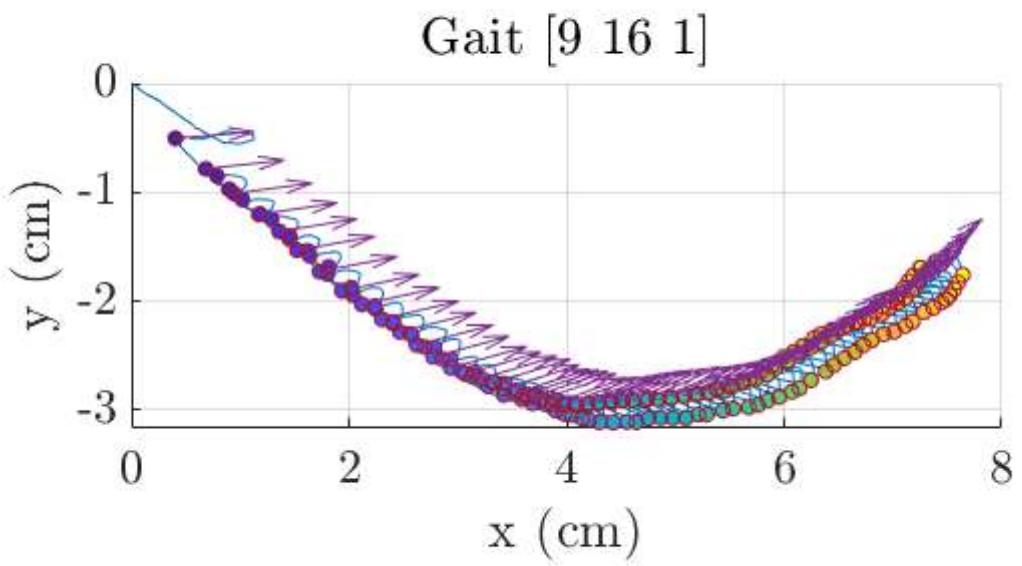
Instantaneous center of rotation IC



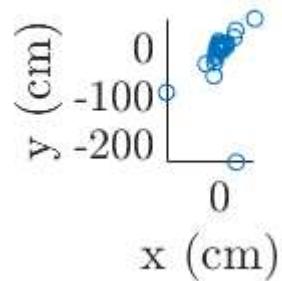
Radius of curvature



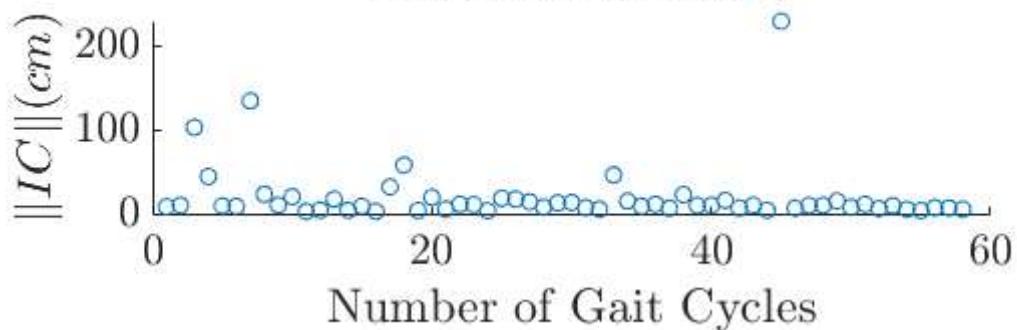
Experiment 8 : 60 cycles of Gait E with light sheath tether (left , not following), trial 1



Instantaneous center of rotation IC

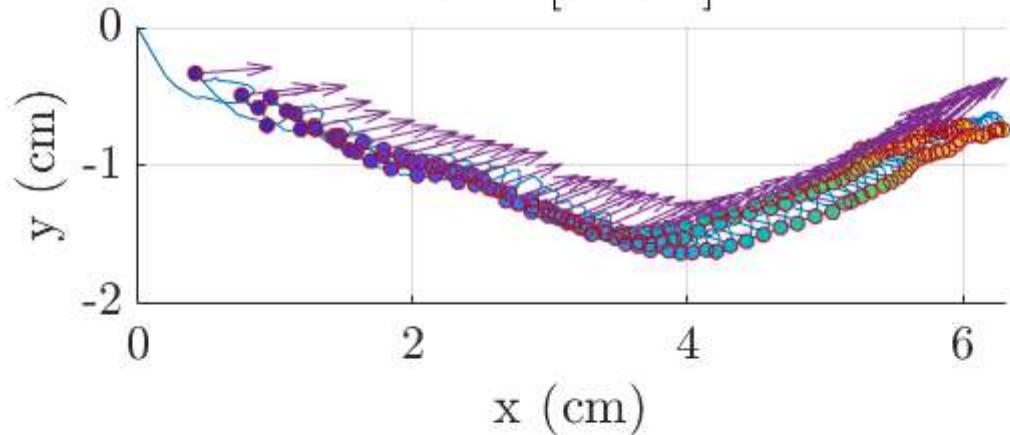


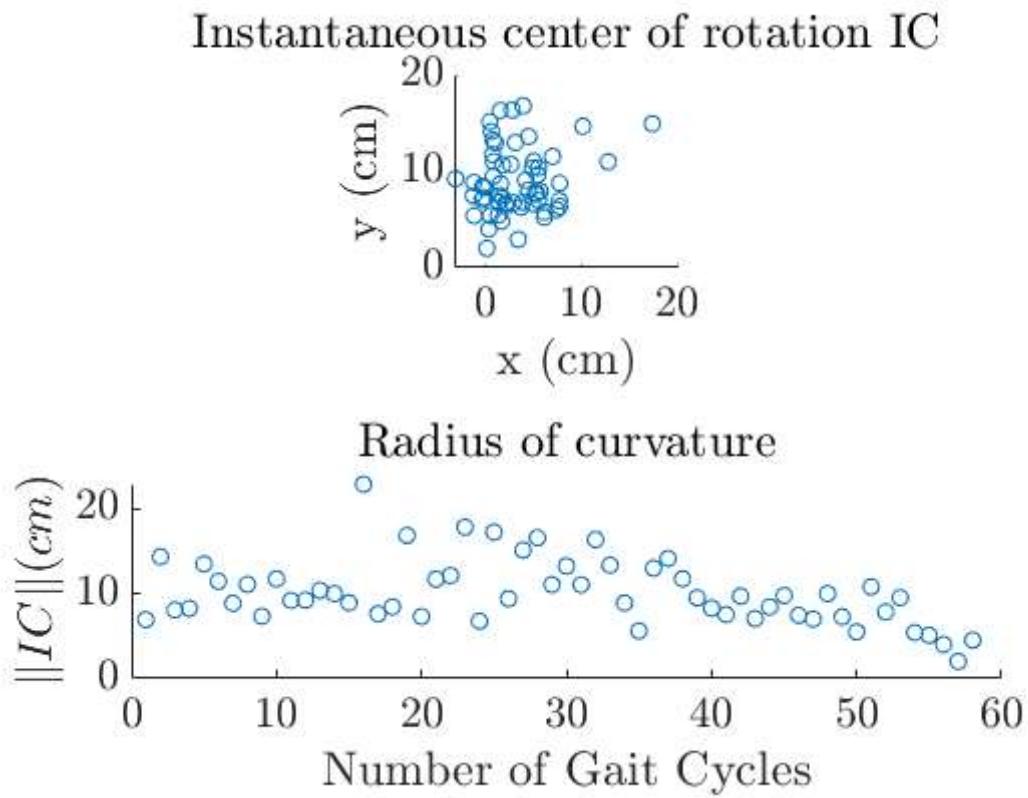
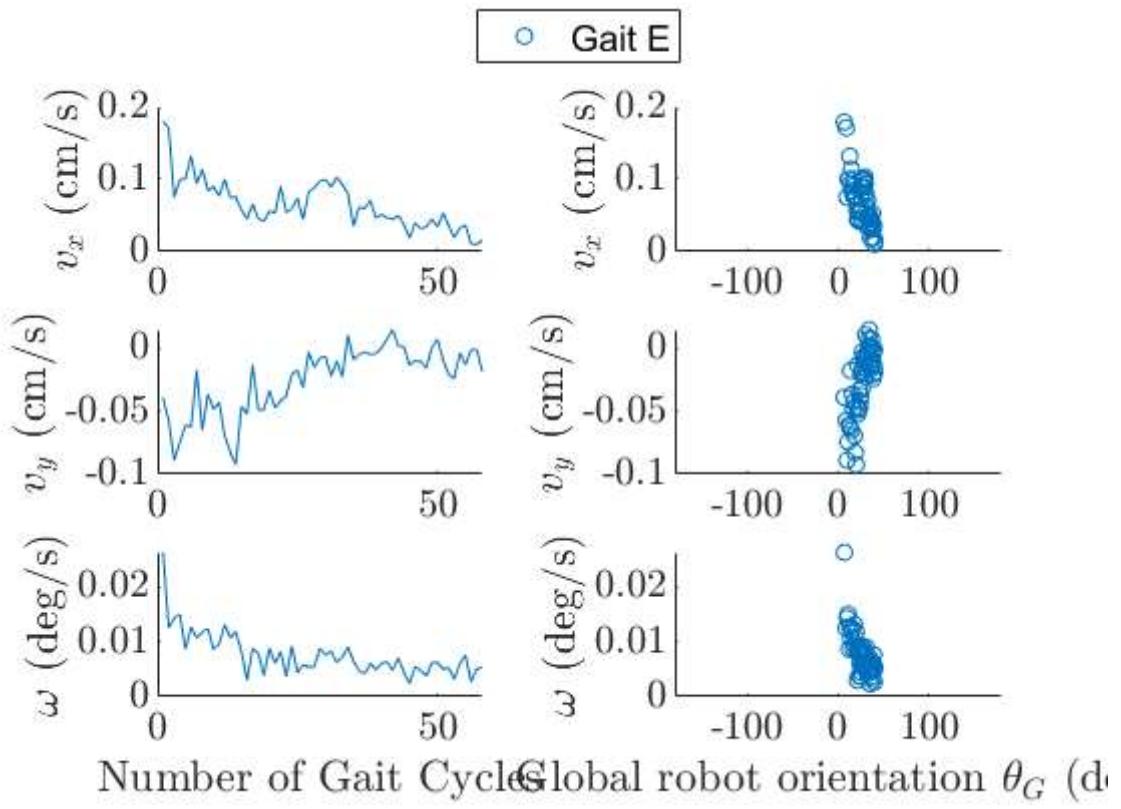
Radius of curvature



Experiment 9 : 60 cycles of Gait E with light sheath tether (right , not following), trial 1

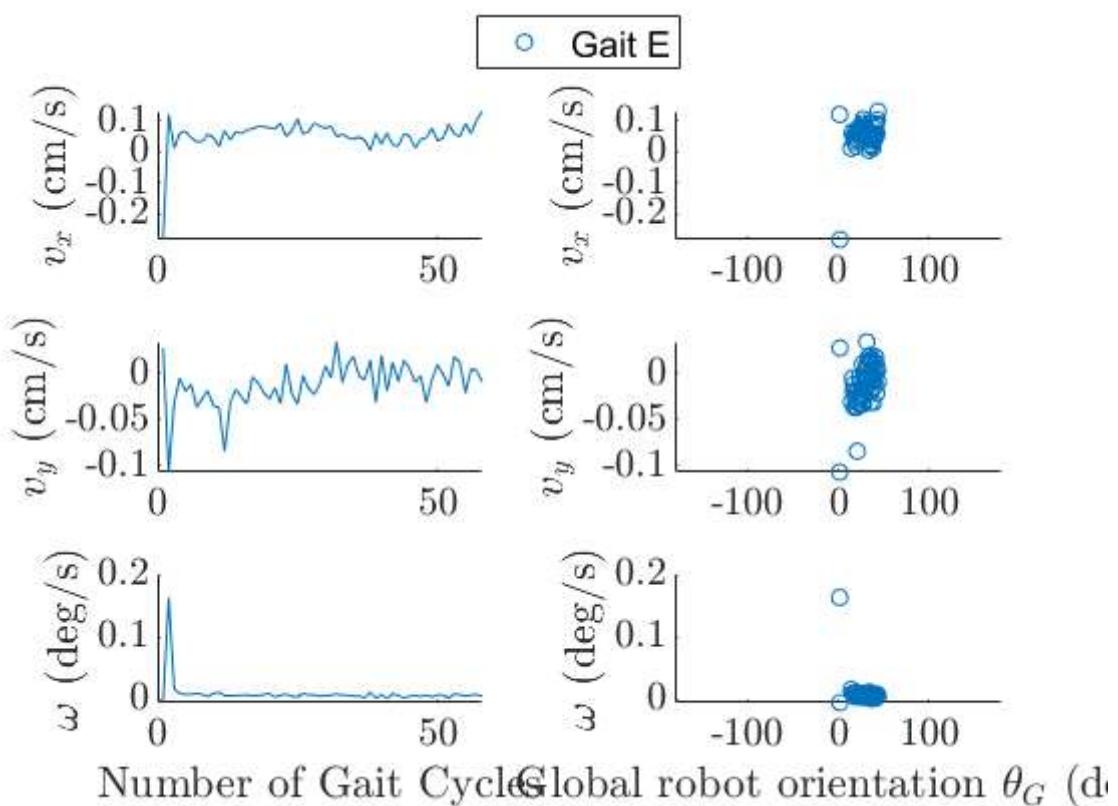
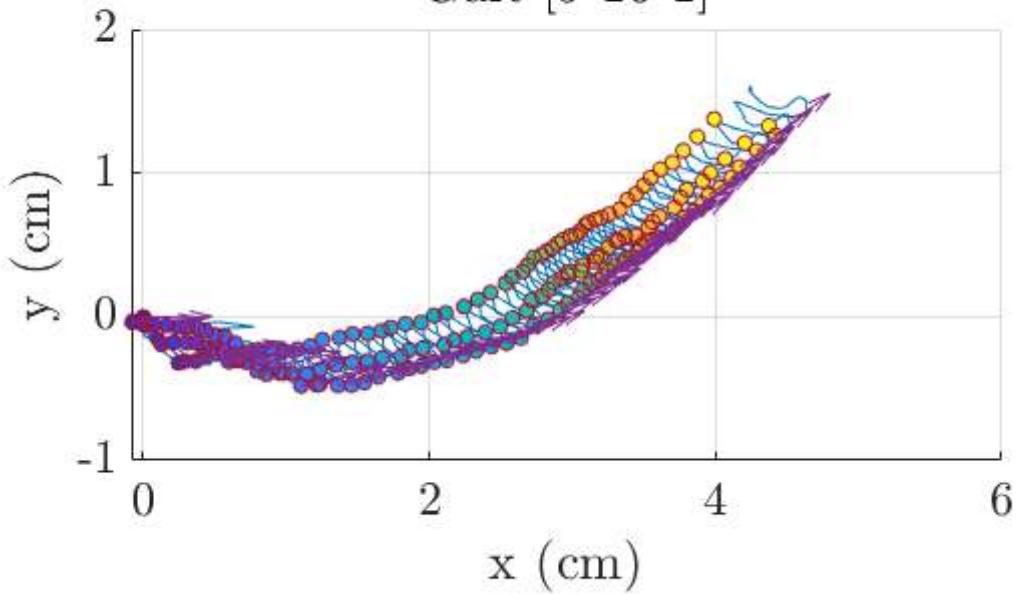
Gait [9 16 1]



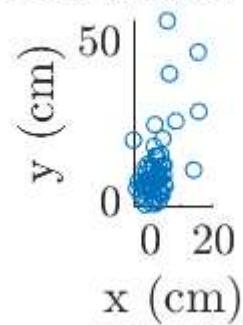


Experiment 10 : 60 cycles of Gait E with no sheath tether (left , not following), trial 1

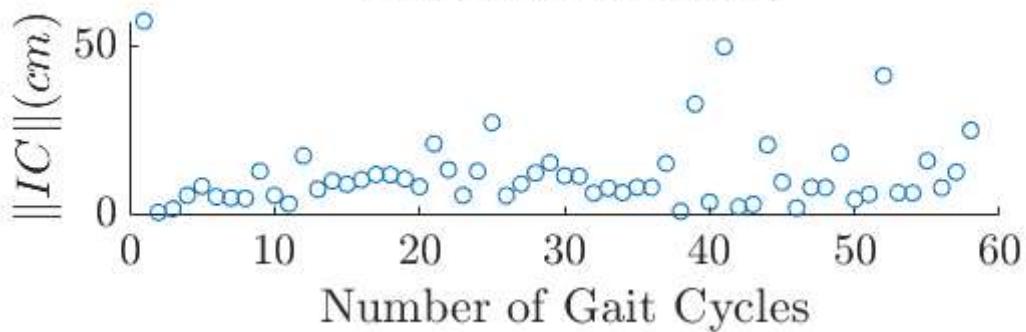
Gait [9 16 1]



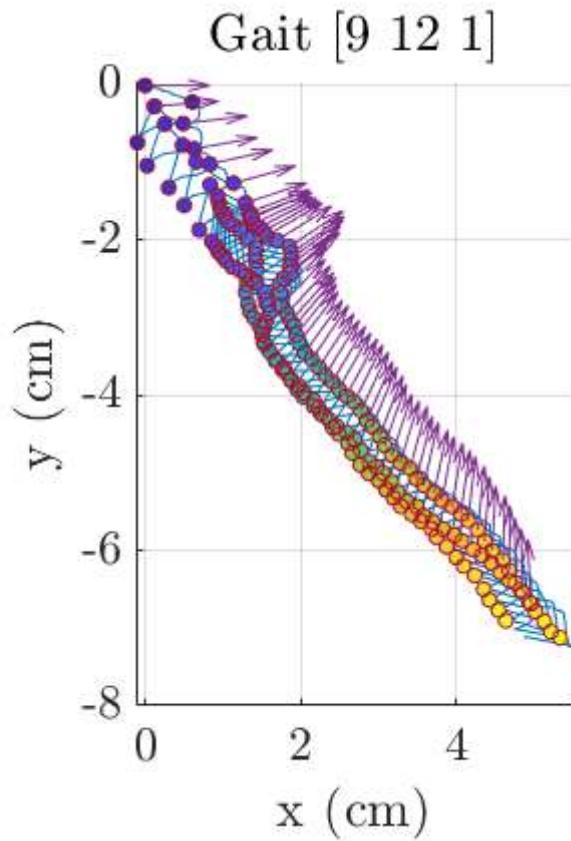
Instantaneous center of rotation IC

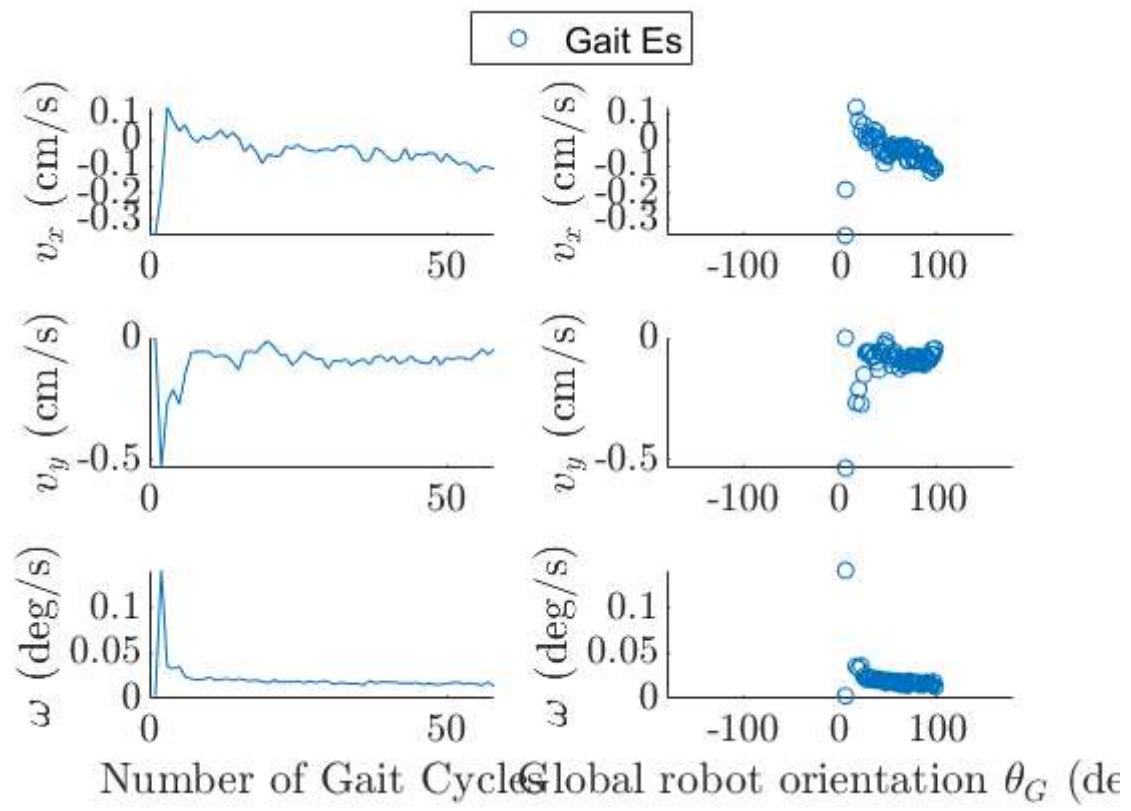


Radius of curvature

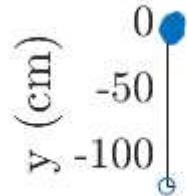


Experiment 11 : 60 cycles of Gait Es with no sheath tether (right , not following), trial 1

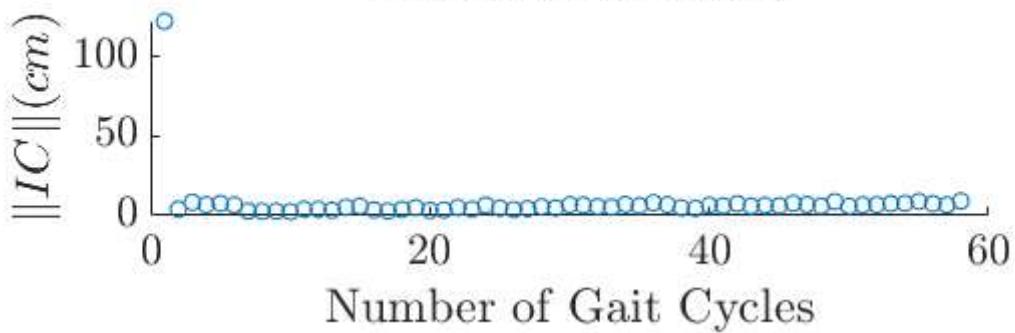




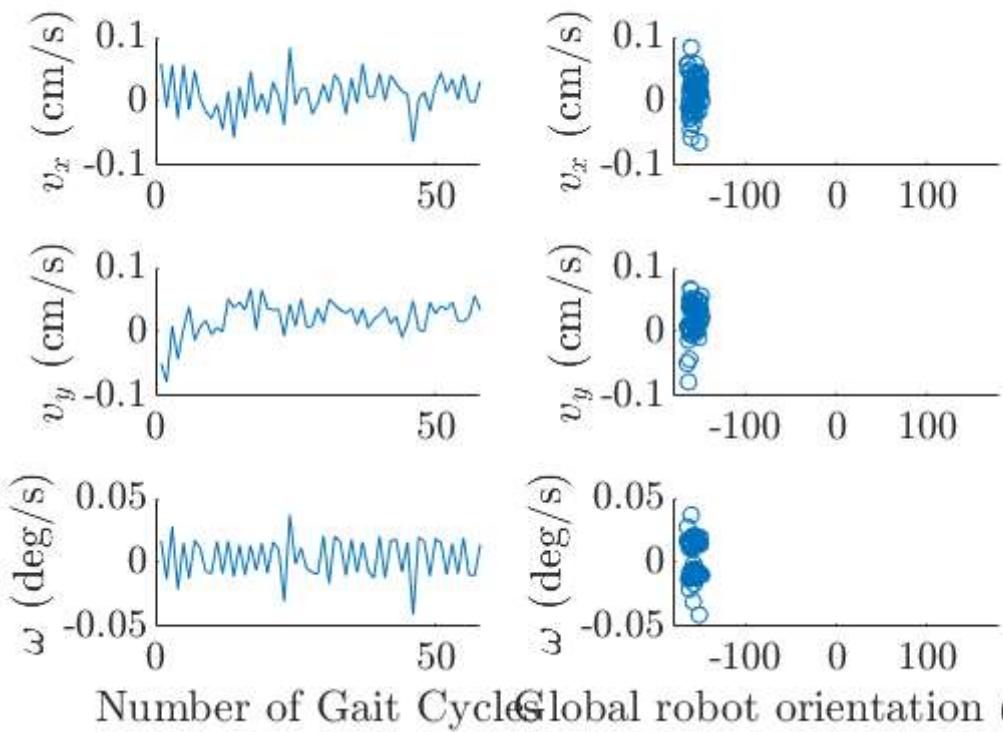
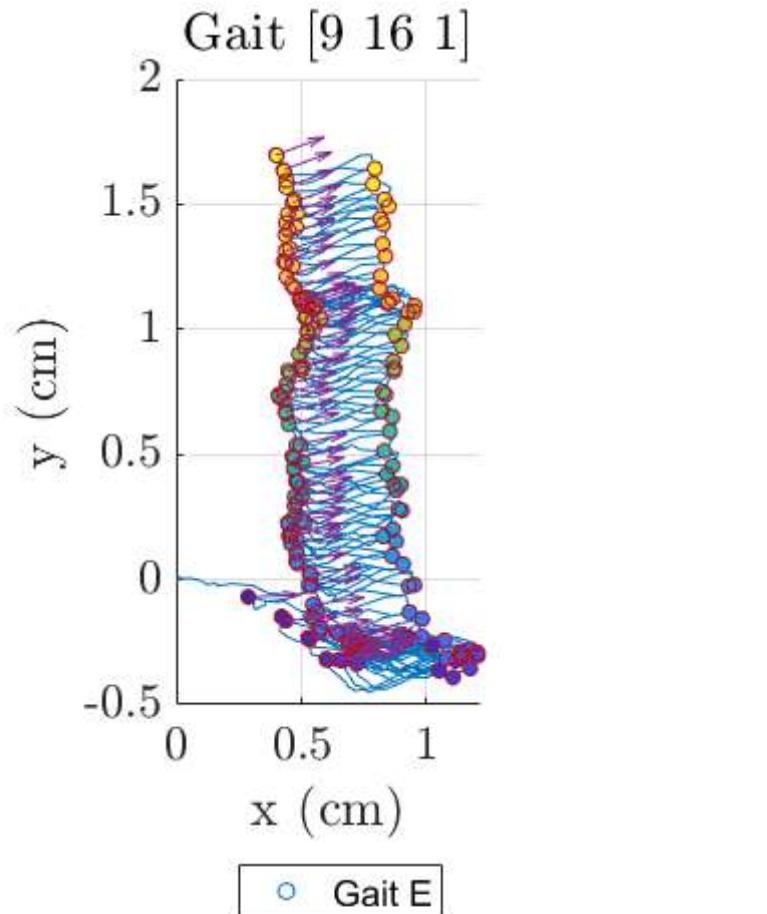
Instantaneous center of rotation IC



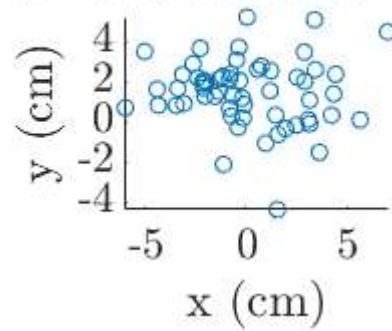
Radius of curvature



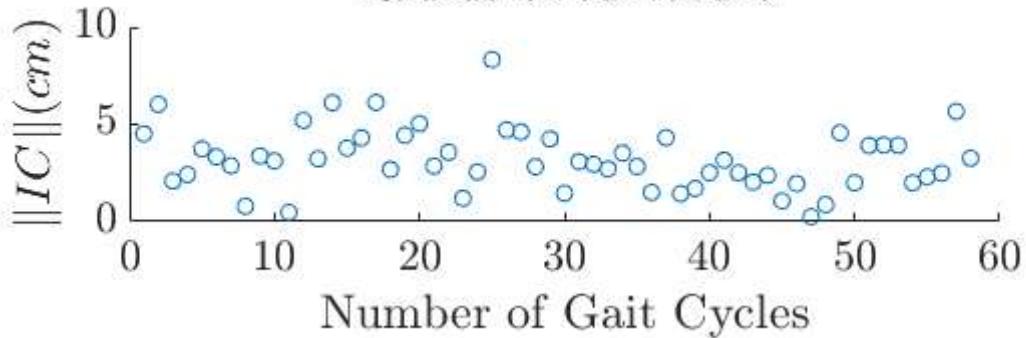
Experiment 12 : 60 cycles of Gait E with no sheath tether (Lf , not following), trial 1



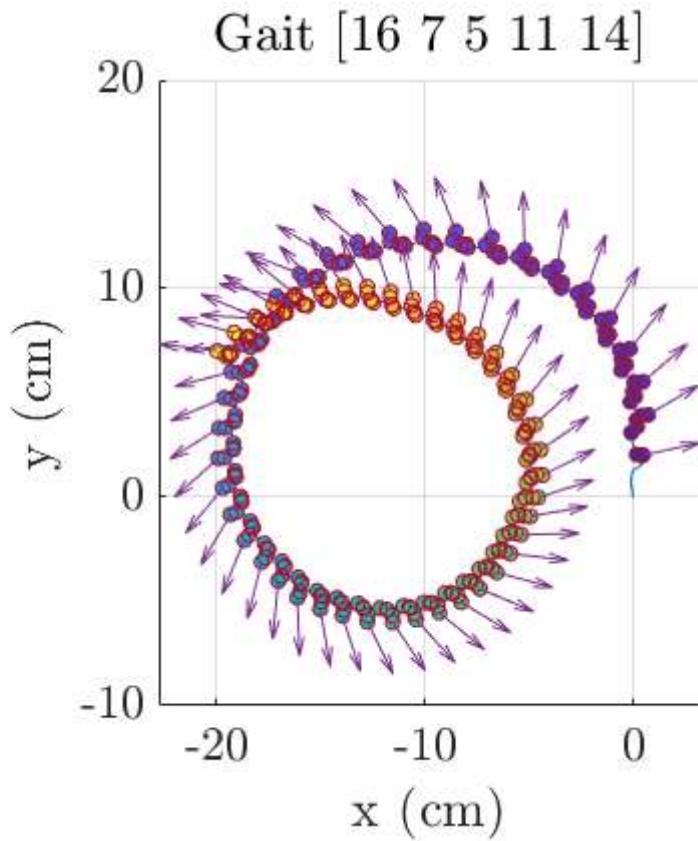
Instantaneous center of rotation IC

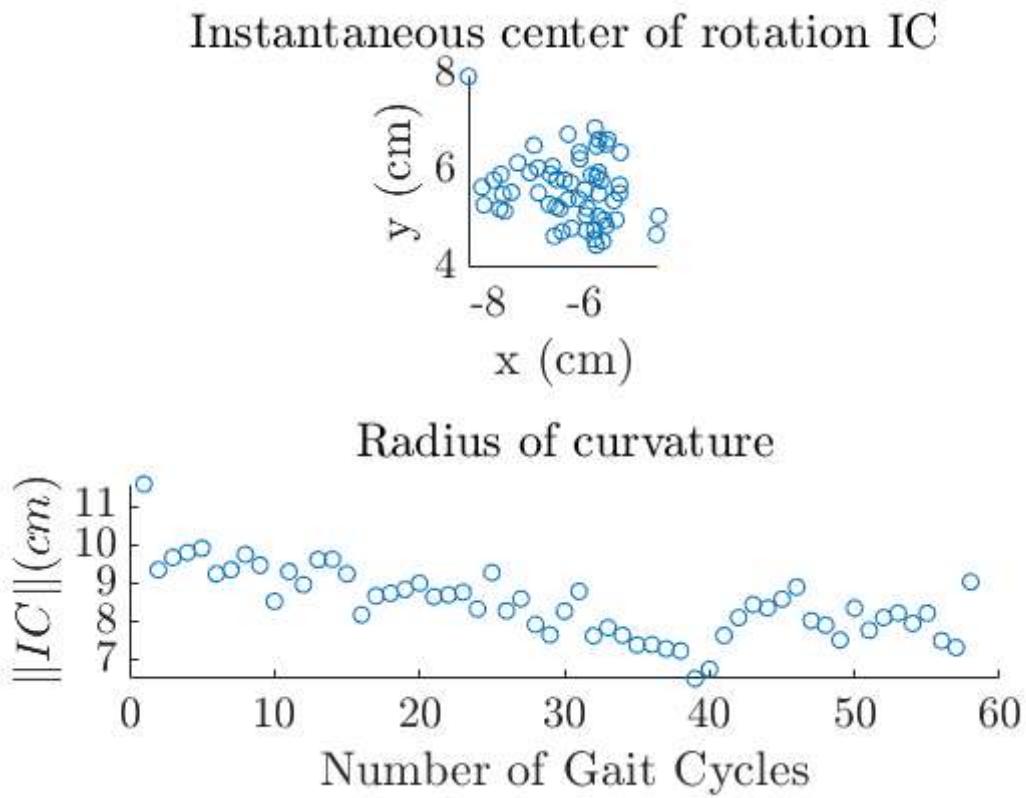
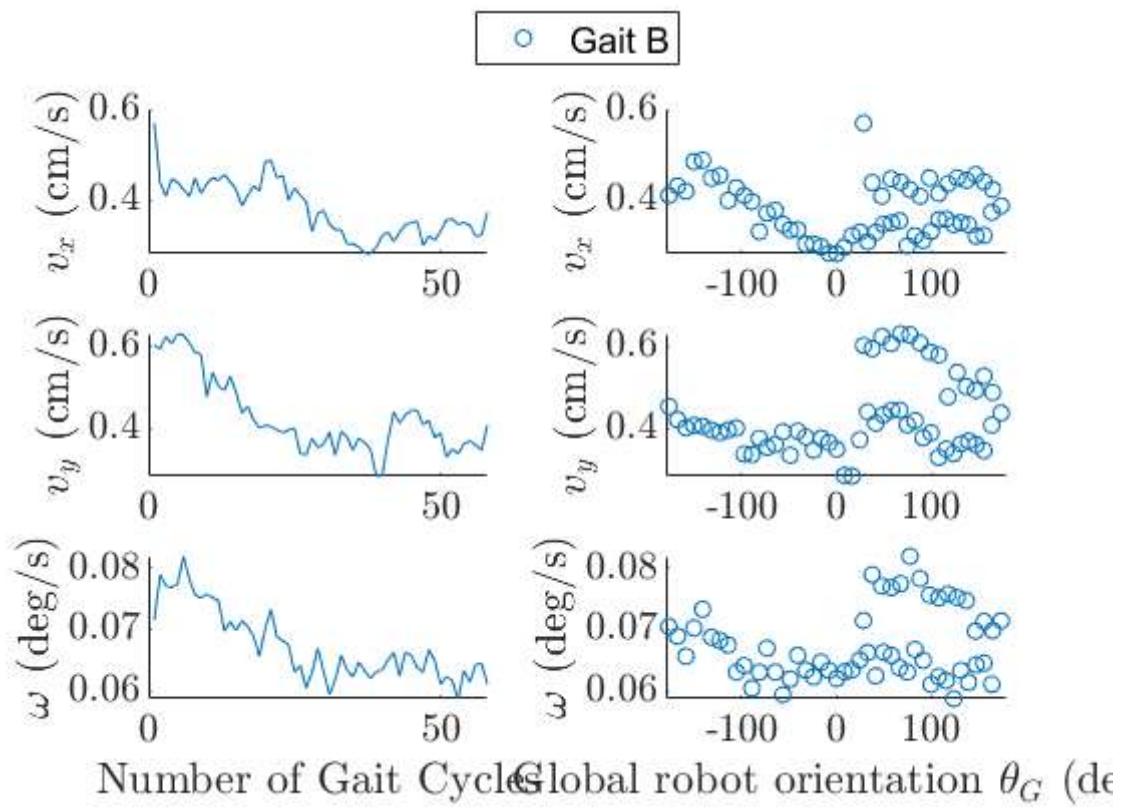


Radius of curvature

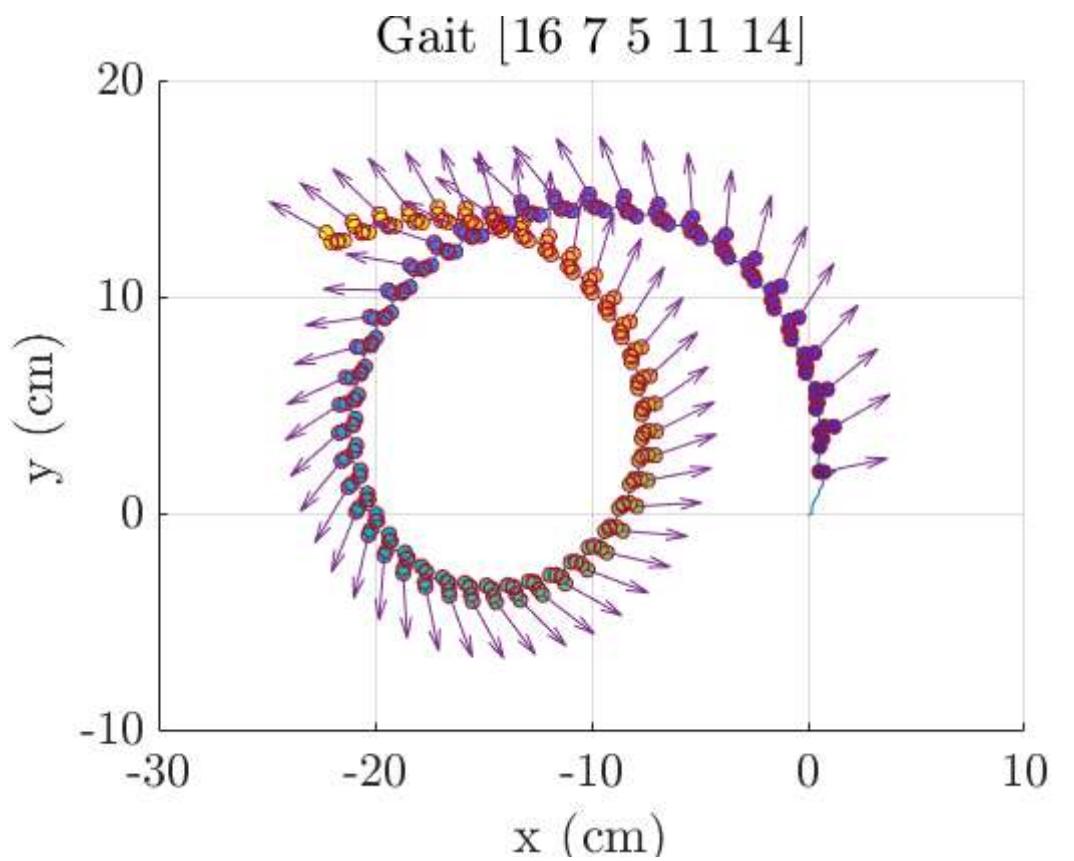


Experiment 13 : 60 cycles of Gait B with light sheath tether (left , following), trial 1

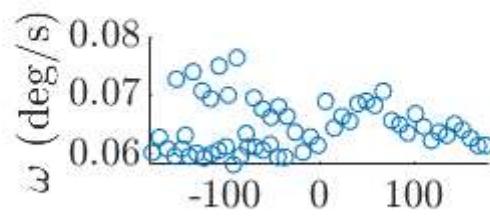
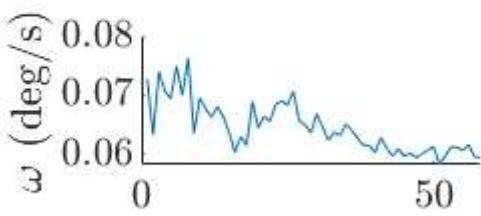
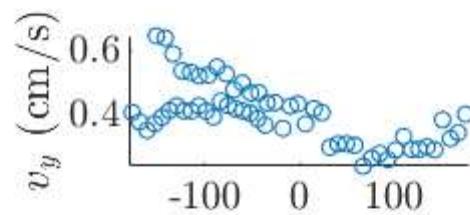
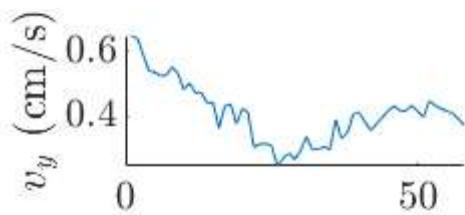
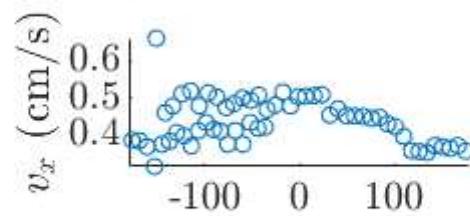
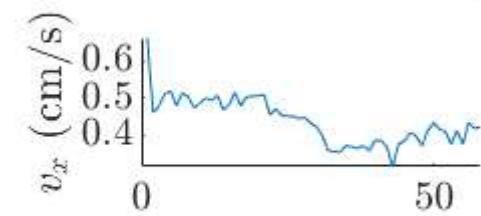




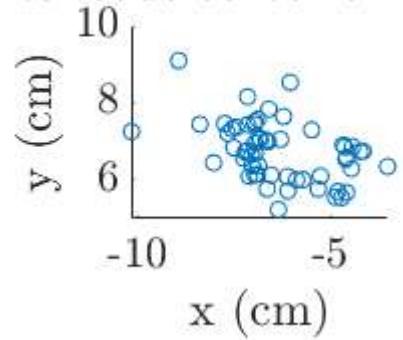
Experiment 14 : 60 cycles of Gait B with light sheath tether (Lf , following), trial 1



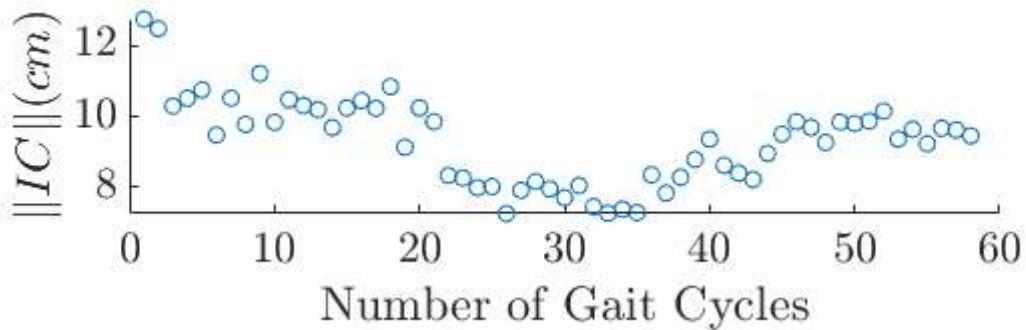
○ Gait B



Instantaneous center of rotation IC

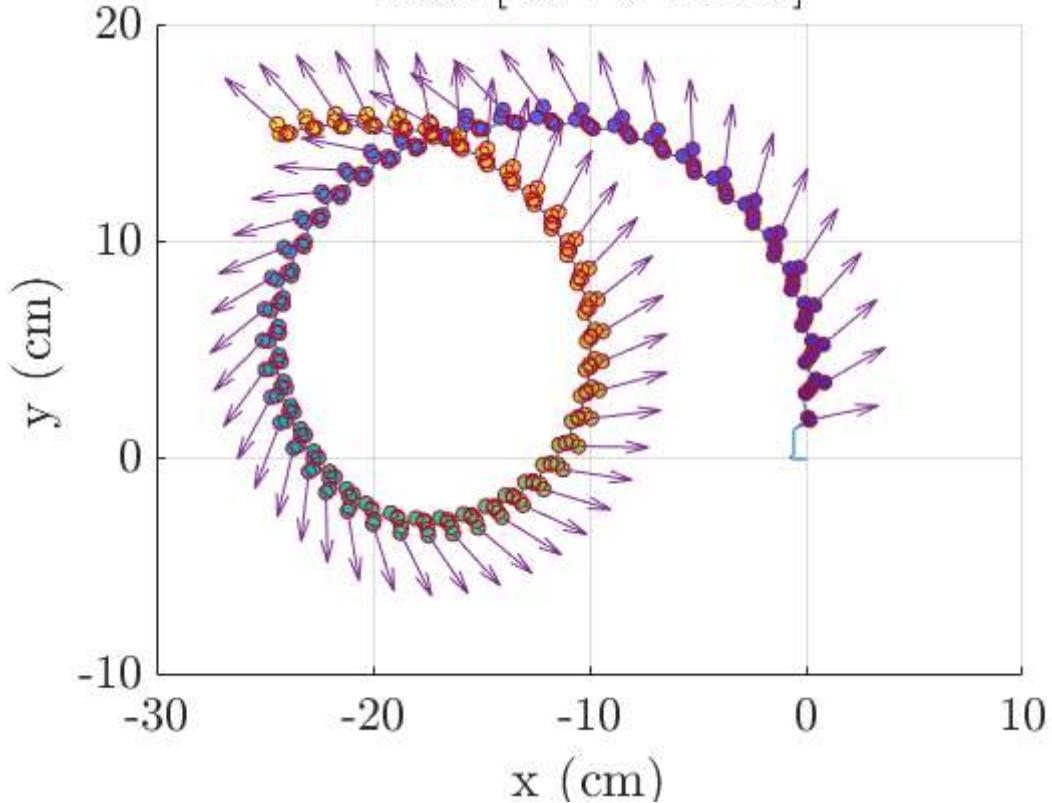


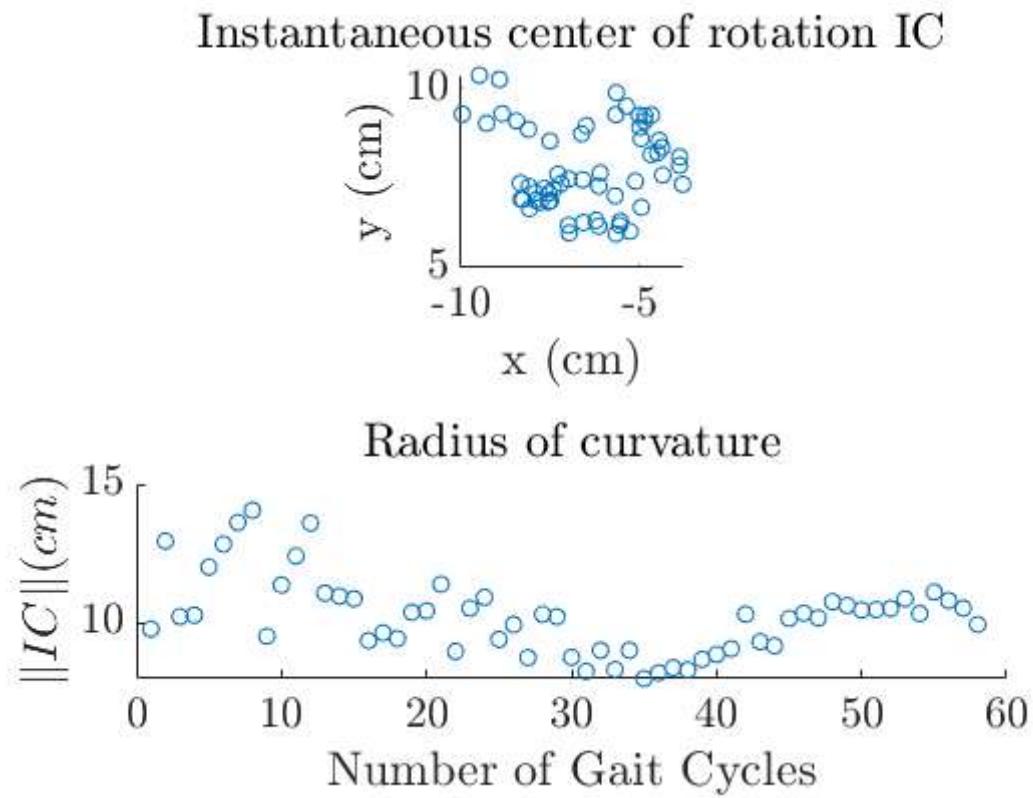
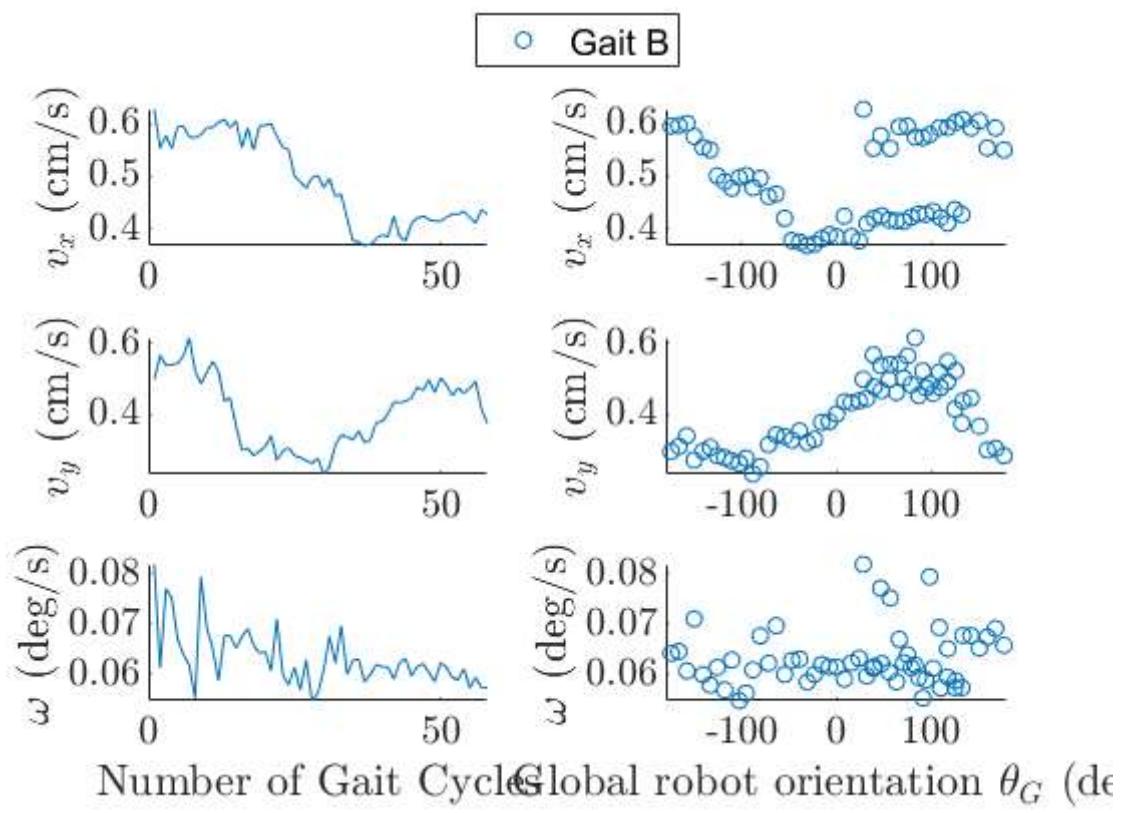
Radius of curvature



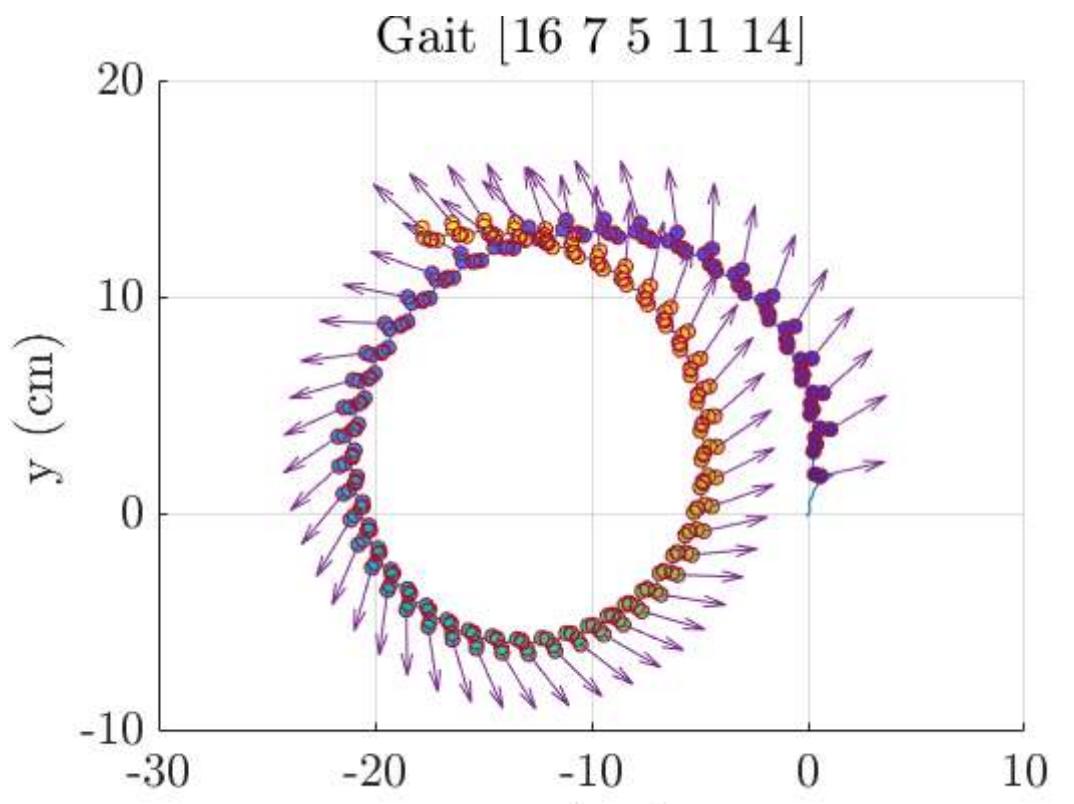
Experiment 15 : 60 cycles of Gait B with light sheath tether (left , not following), trial 1

Gait [16 7 5 11 14]

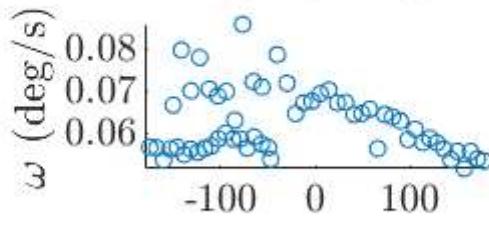
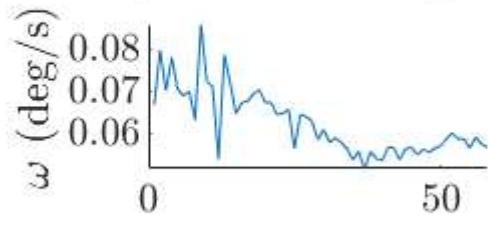
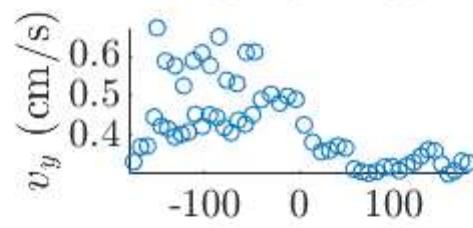
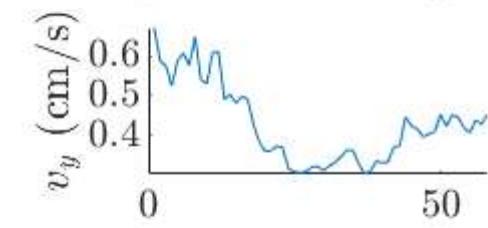
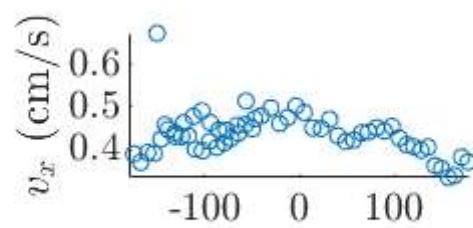
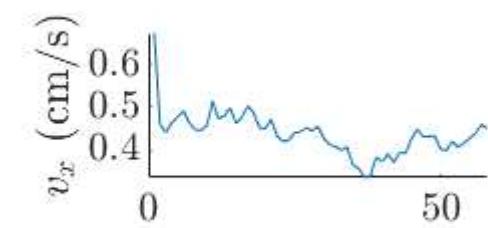




Experiment 16 : 60 cycles of Gait B with light sheath tether (Lf , not following), trial 1

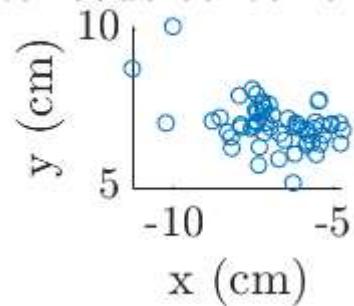


○ Gait B

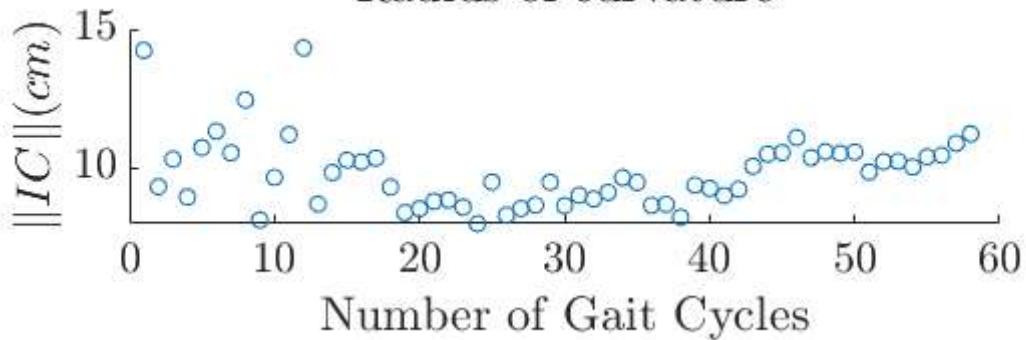


Number of Gait Cycles Global robot orientation θ_G (deg)

Instantaneous center of rotation IC

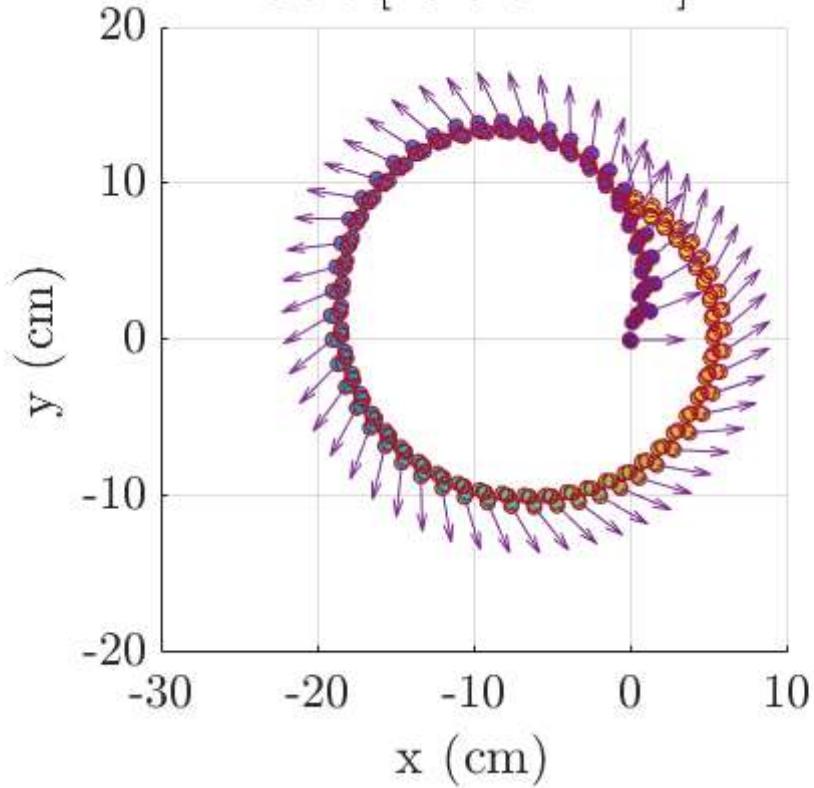


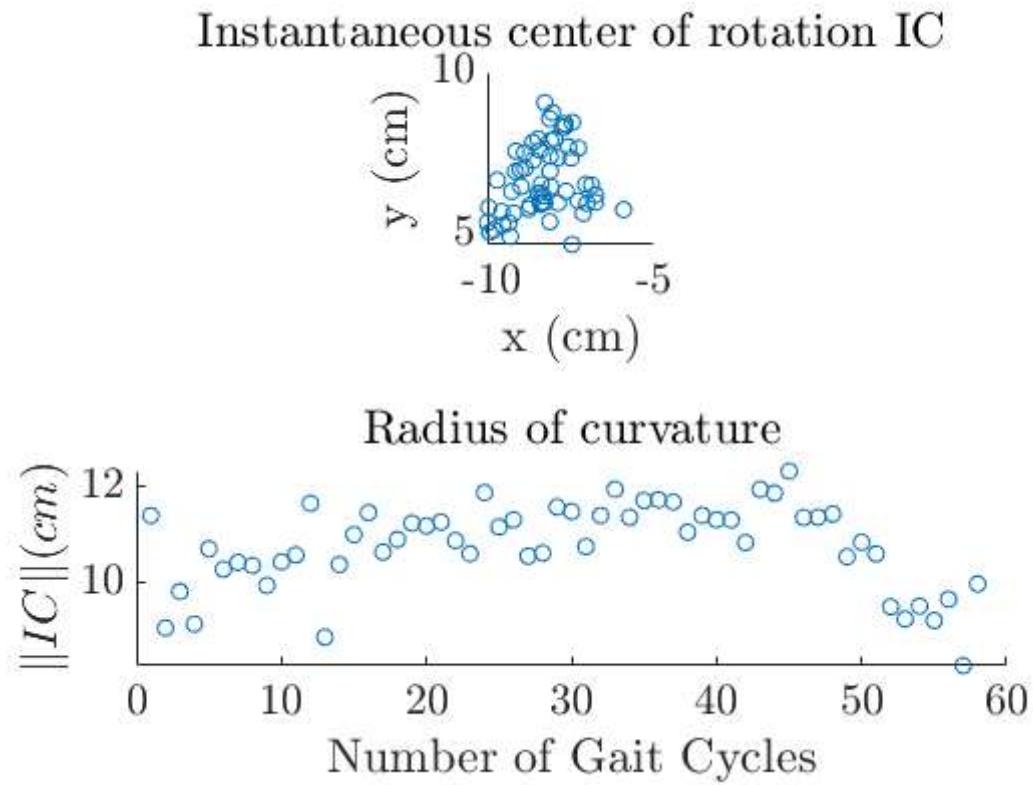
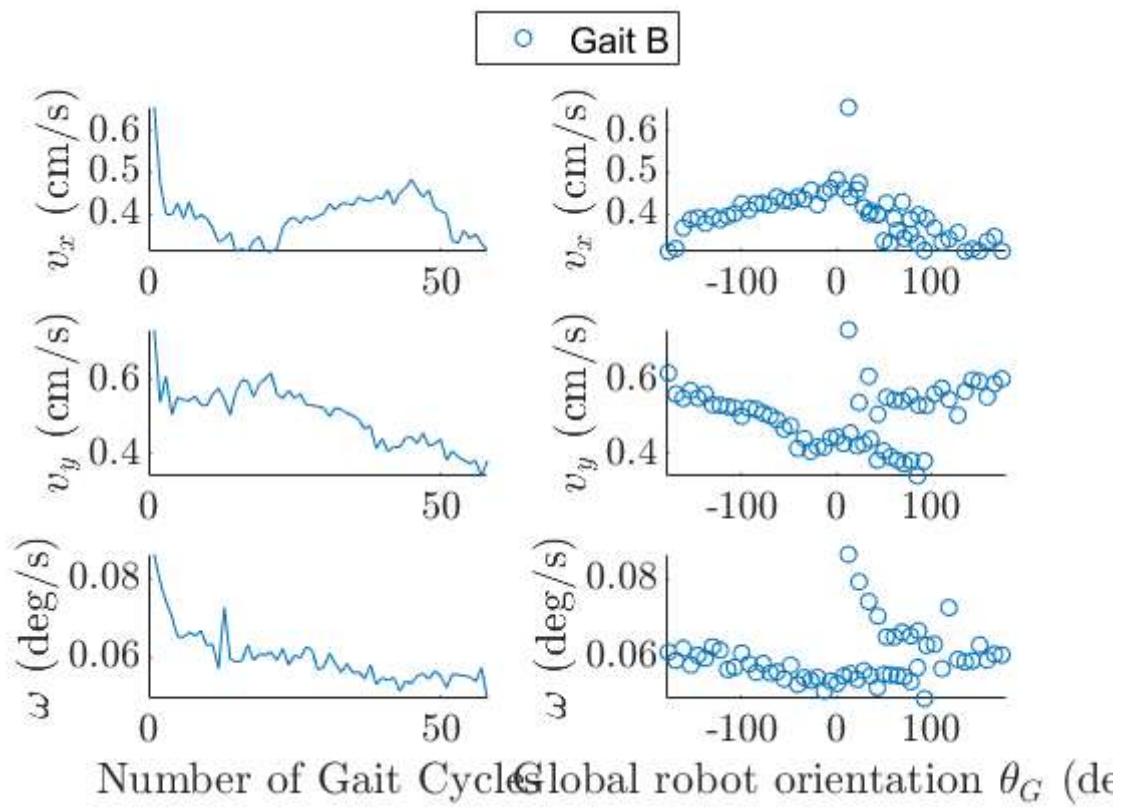
Radius of curvature



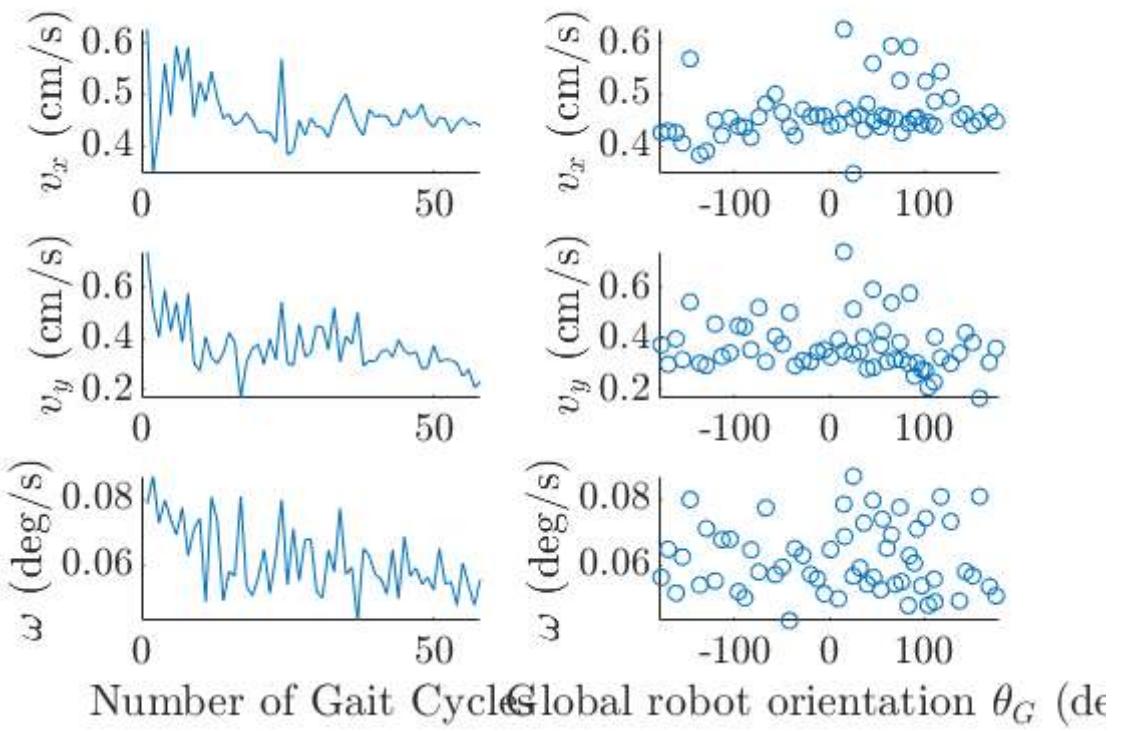
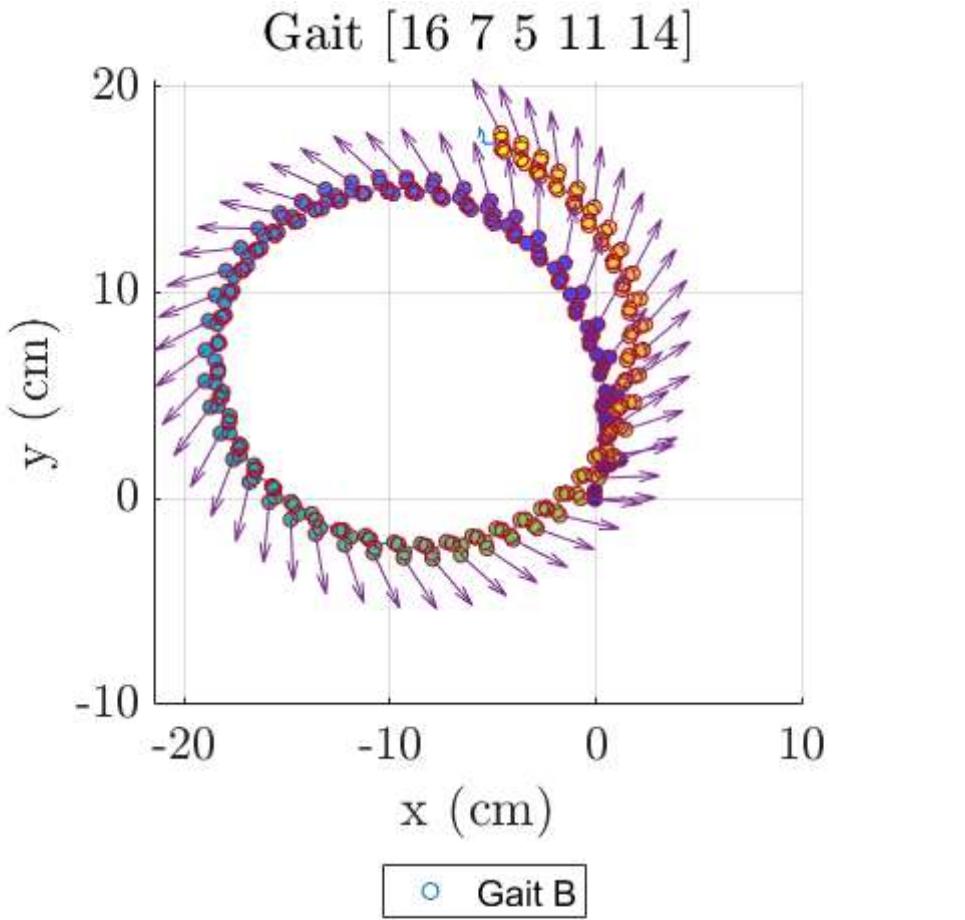
Experiment 17 : 60 cycles of Gait B with light sheath tether (right , not following), trial 1

Gait [16 7 5 11 14]

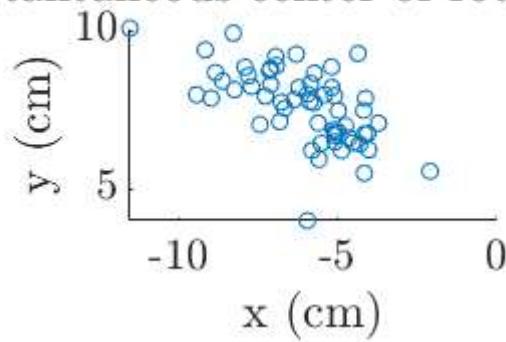




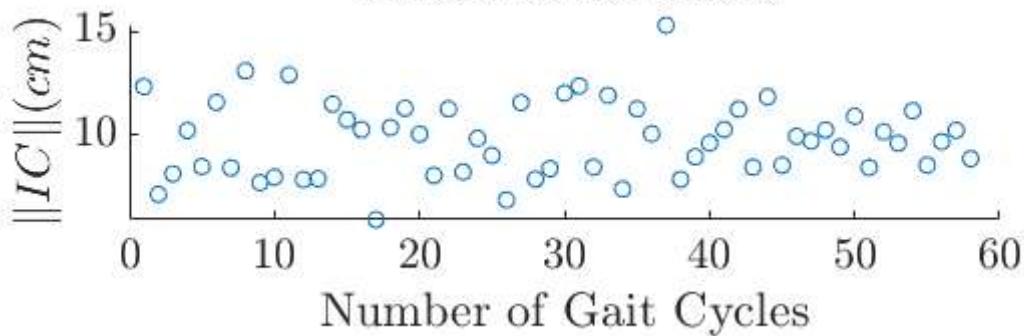
Experiment 18 : 60 cycles of Gait B with no sheath tether (right , following), trial 1



Instantaneous center of rotation IC

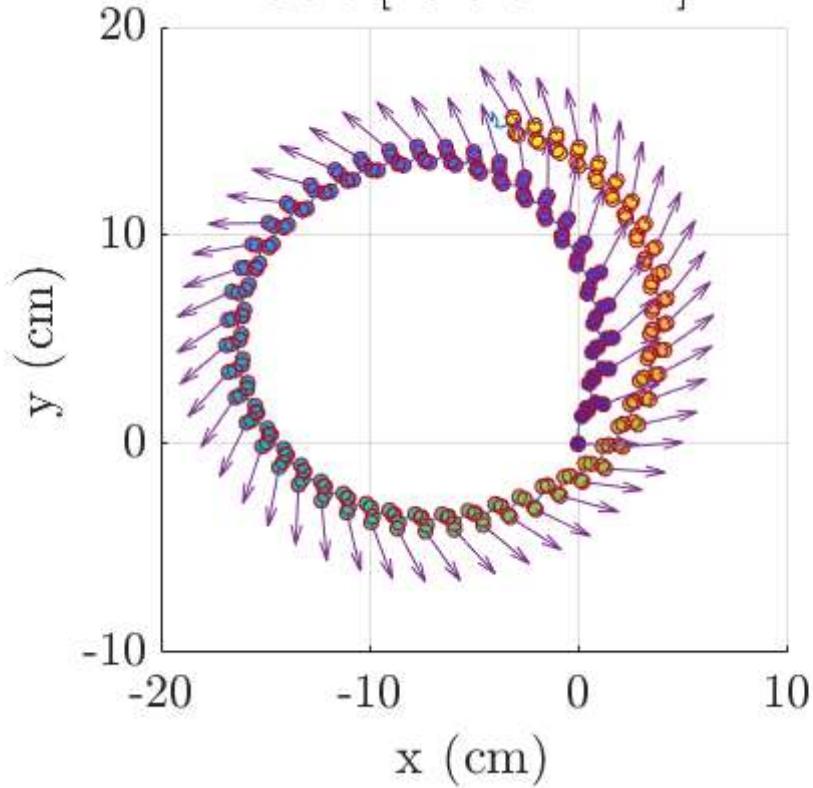


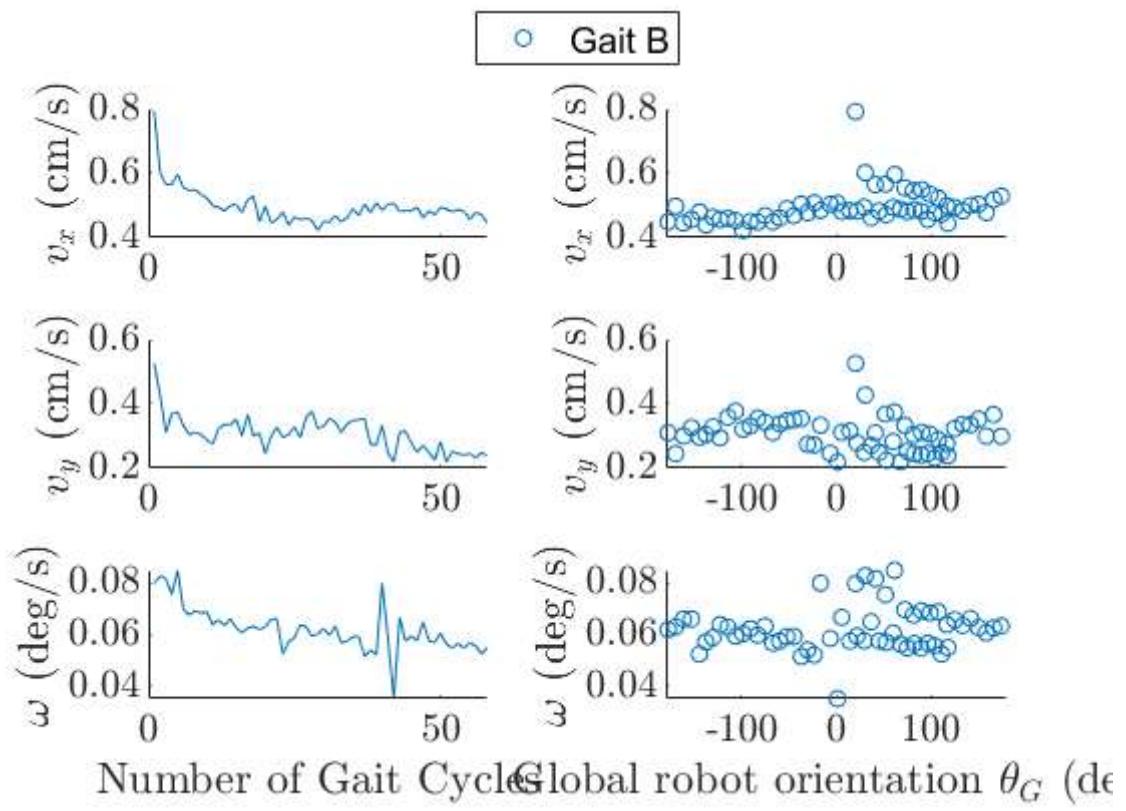
Radius of curvature



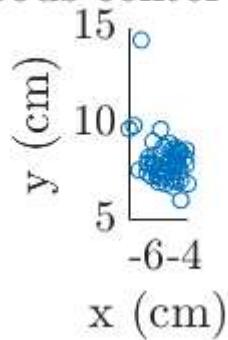
Experiment 19 : 60 cycles of Gait B with no sheath tether (right , following), trial 2

Gait [16 7 5 11 14]

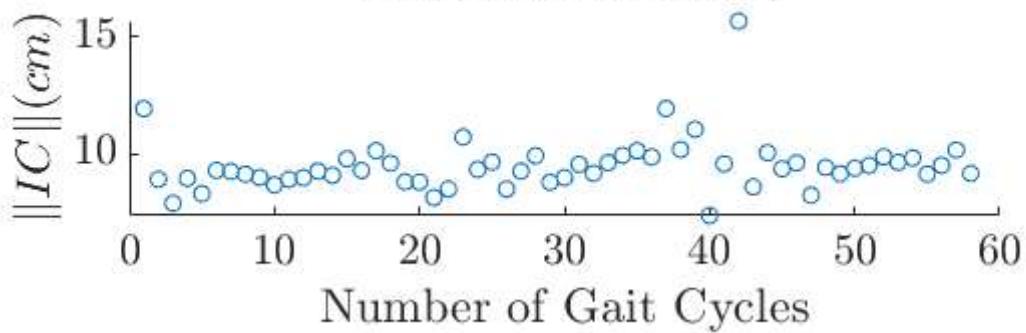




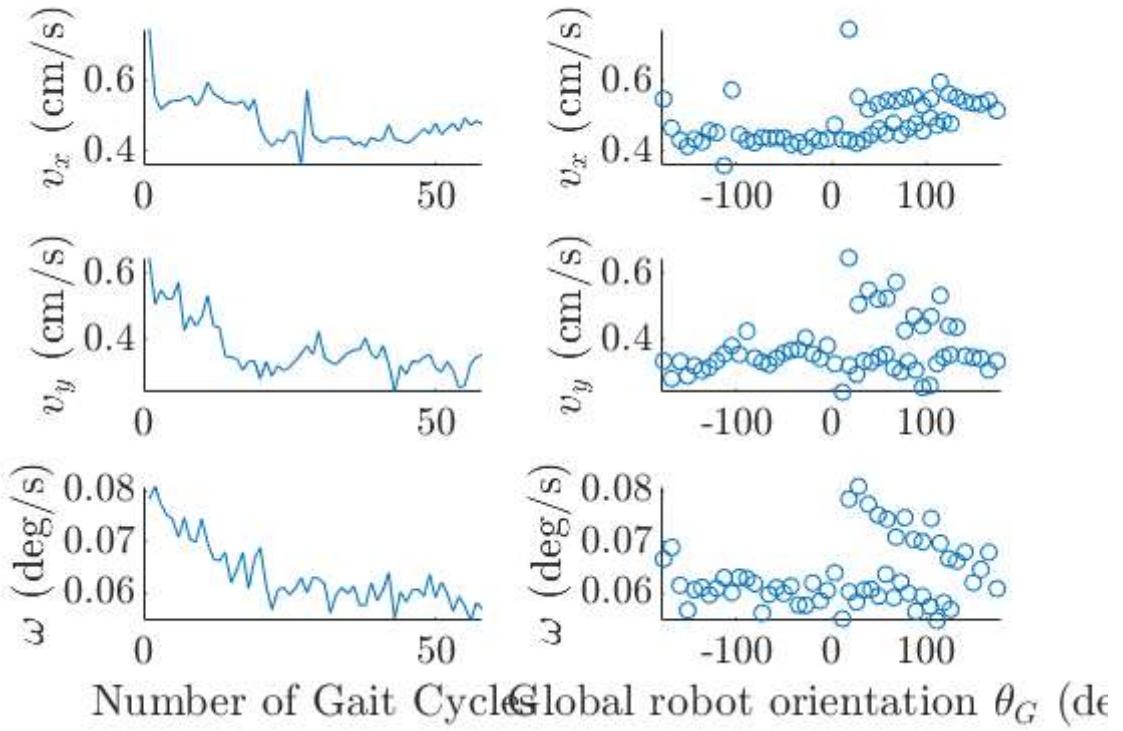
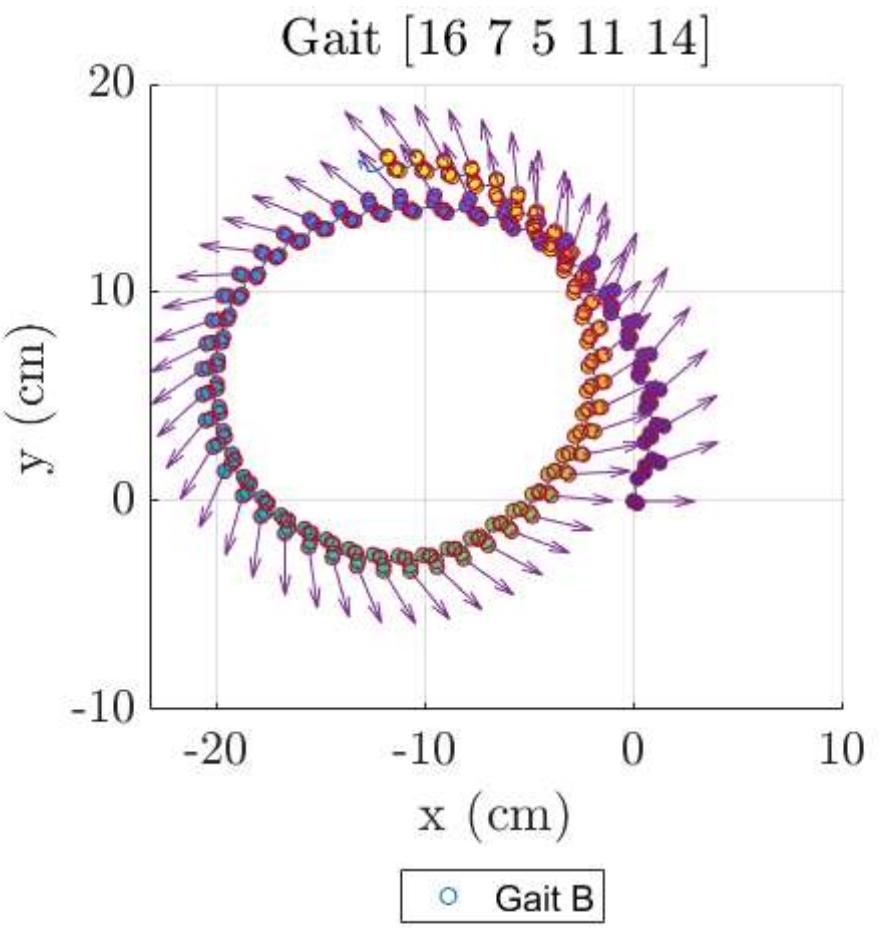
Instantaneous center of rotation IC



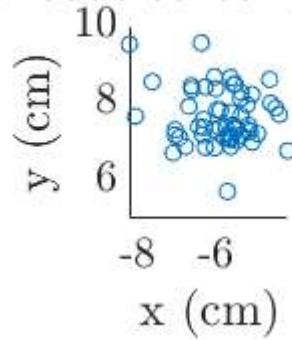
Radius of curvature



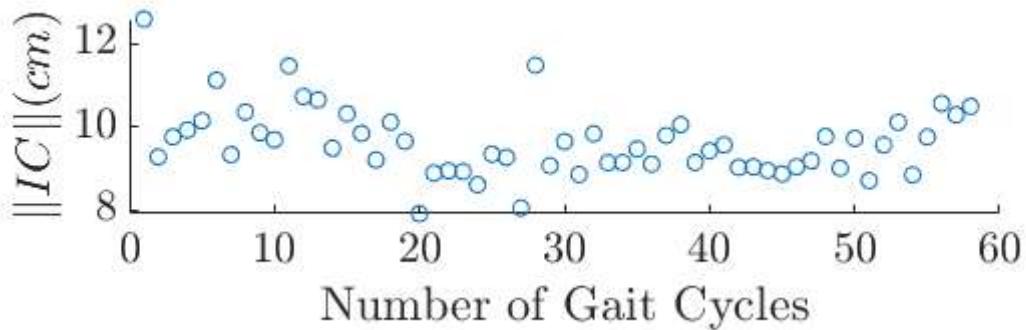
Experiment 20 : 60 cycles of Gait B with no sheath tether (left , following), trial 1



Instantaneous center of rotation IC

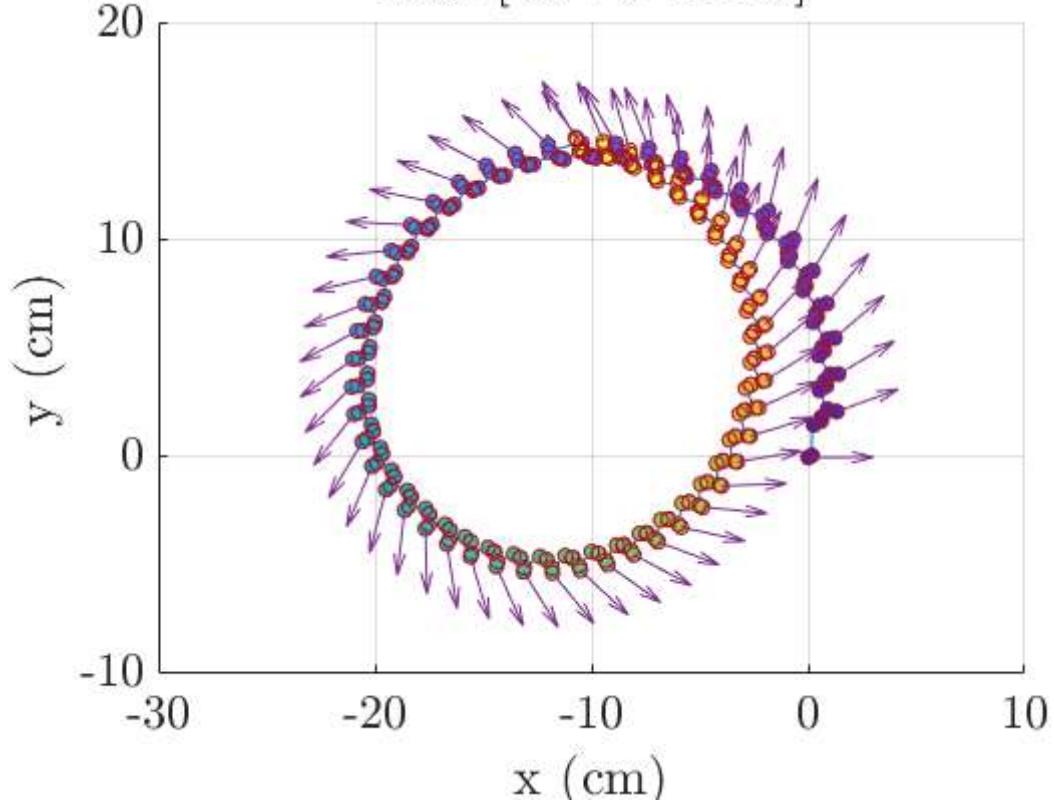


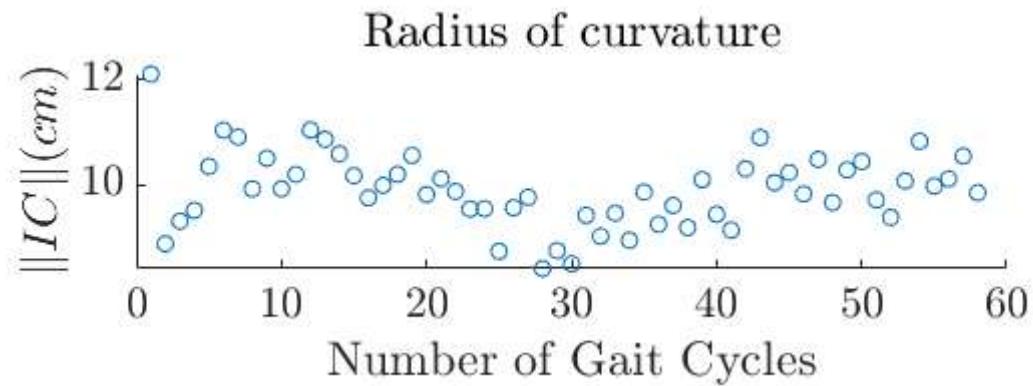
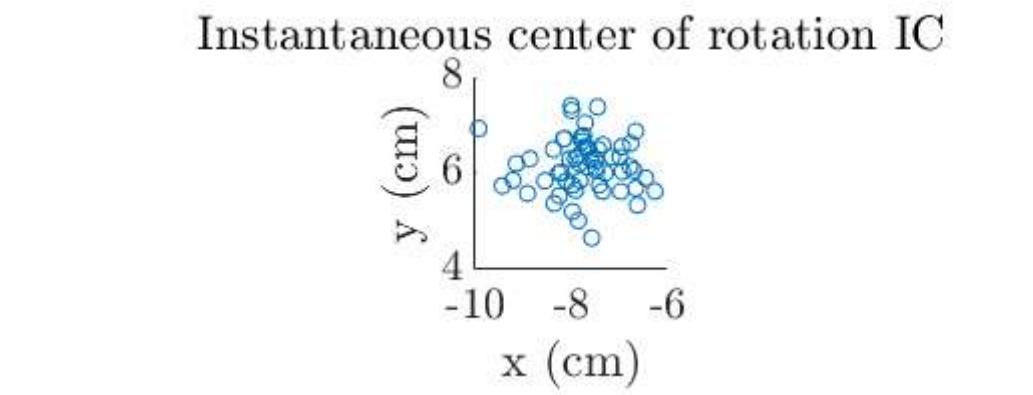
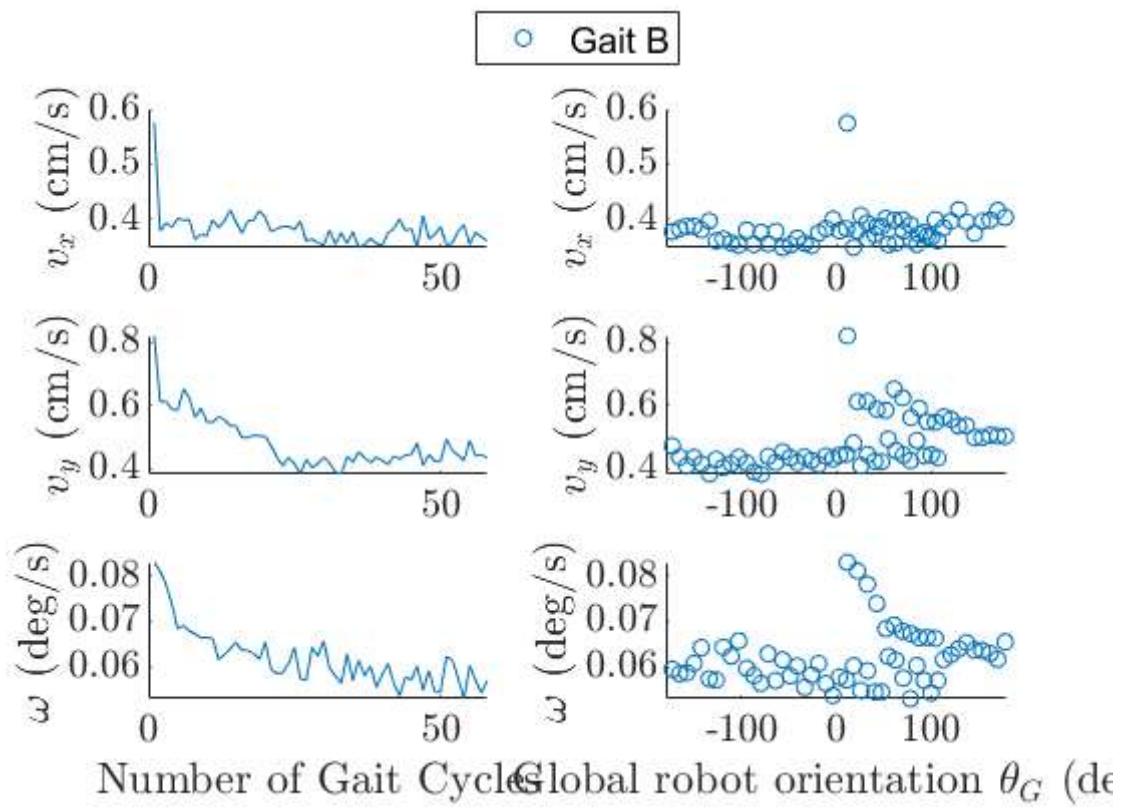
Radius of curvature



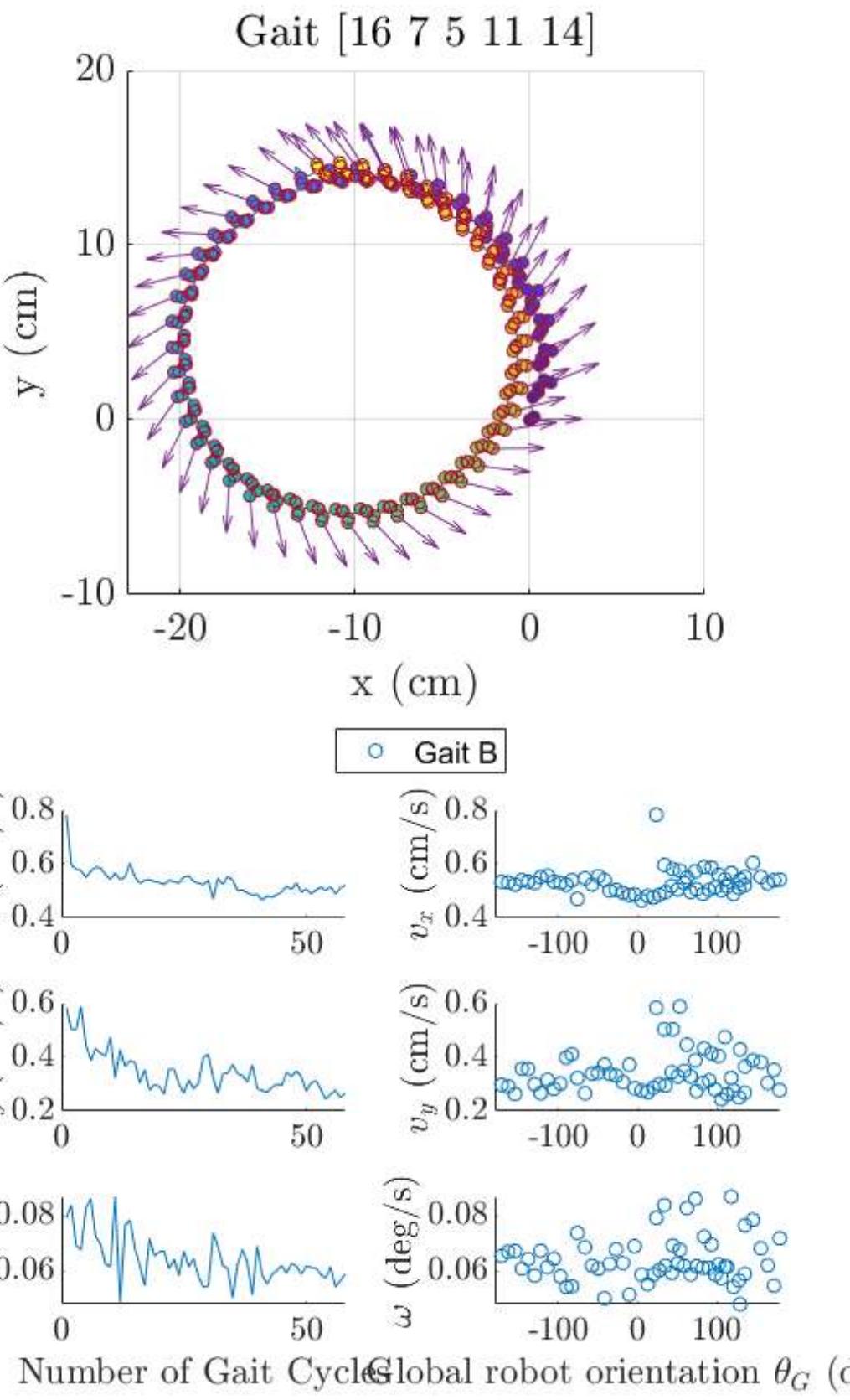
Experiment 21 : 60 cycles of Gait B with no sheath tether (left , following), trial 2

Gait [16 7 5 11 14]

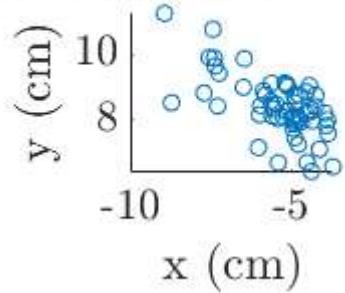




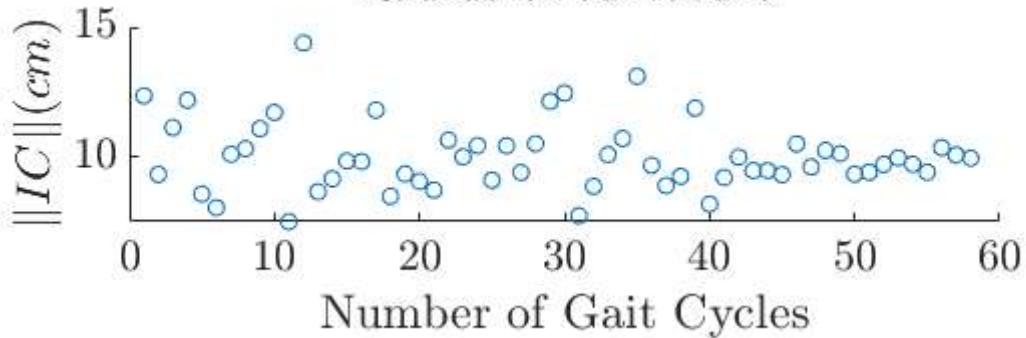
Experiment 22 : 60 cycles of Gait B with no sheath tether (right , not following), trial 1



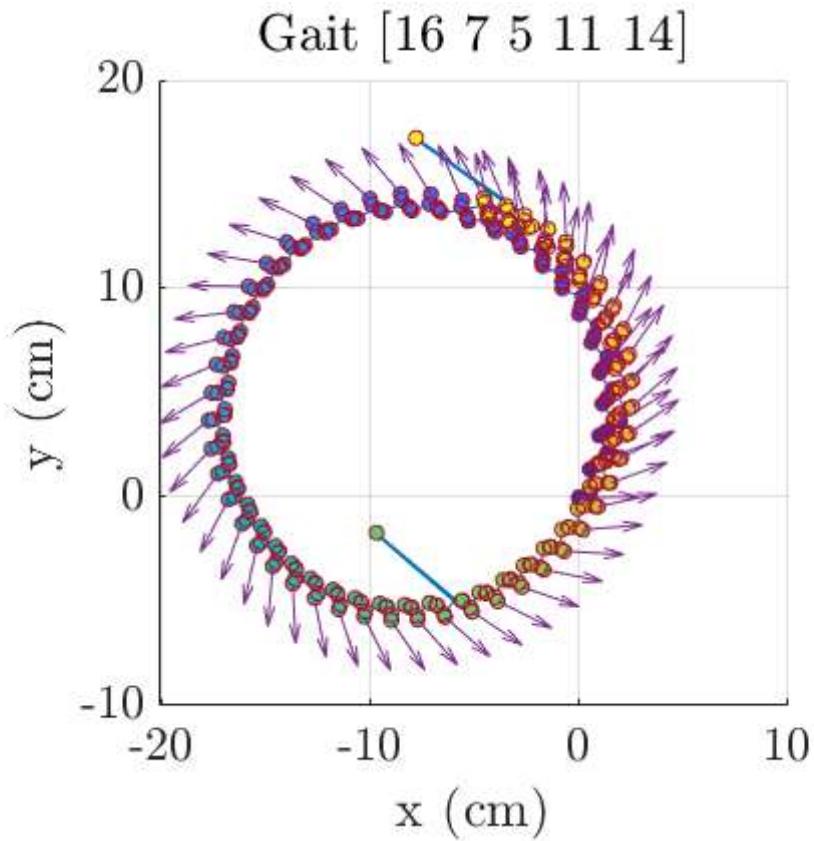
Instantaneous center of rotation IC

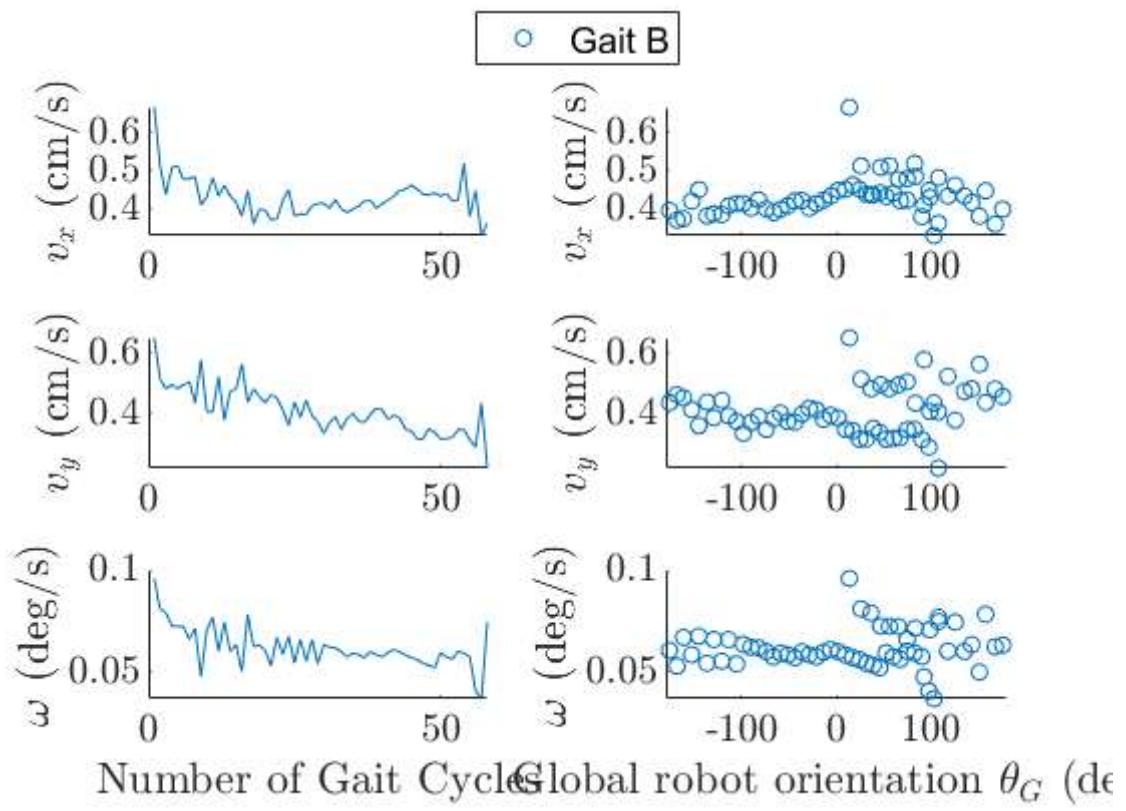


Radius of curvature

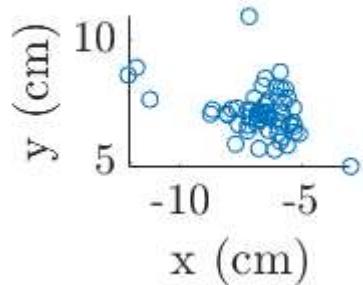


Experiment 23 : 60 cycles of Gait B with no sheath tether (right , not following), trial 2

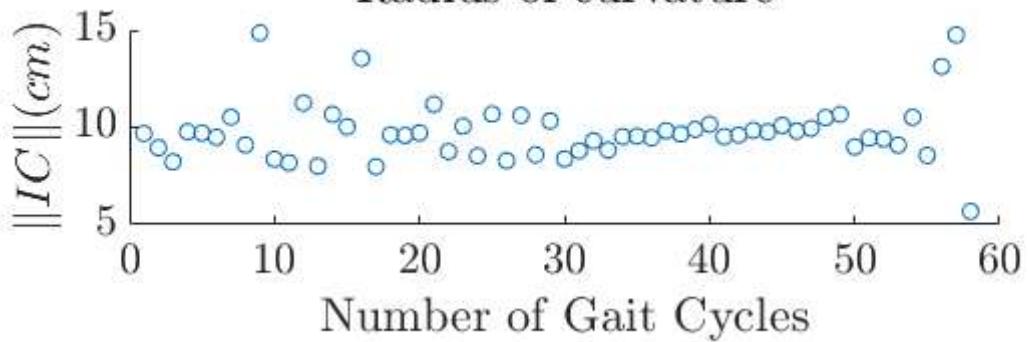




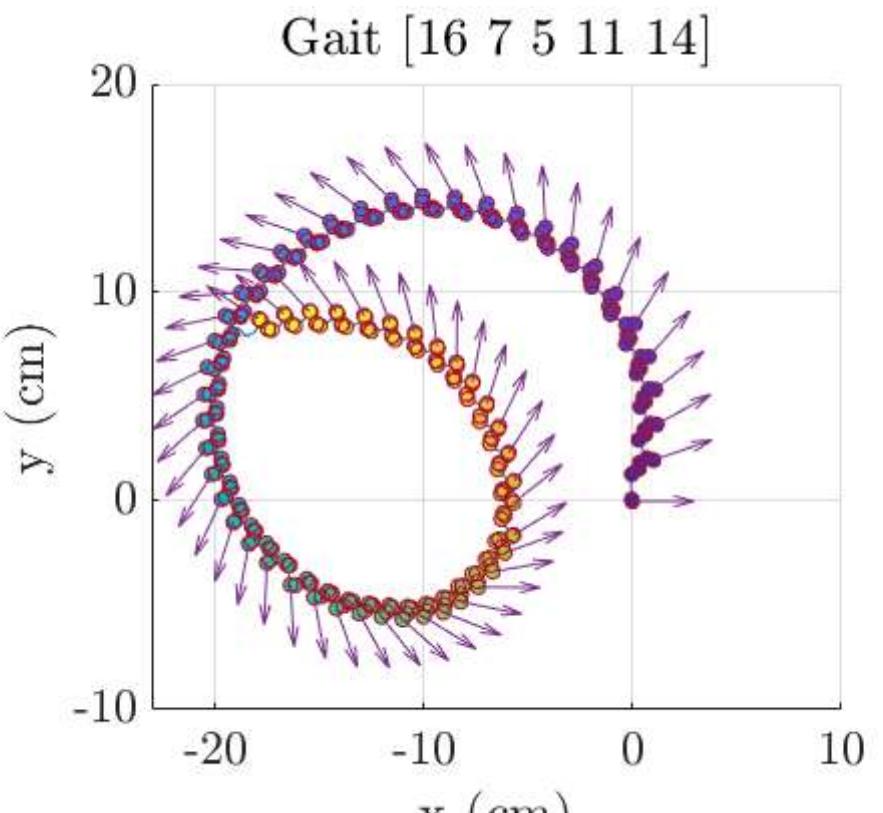
Instantaneous center of rotation IC



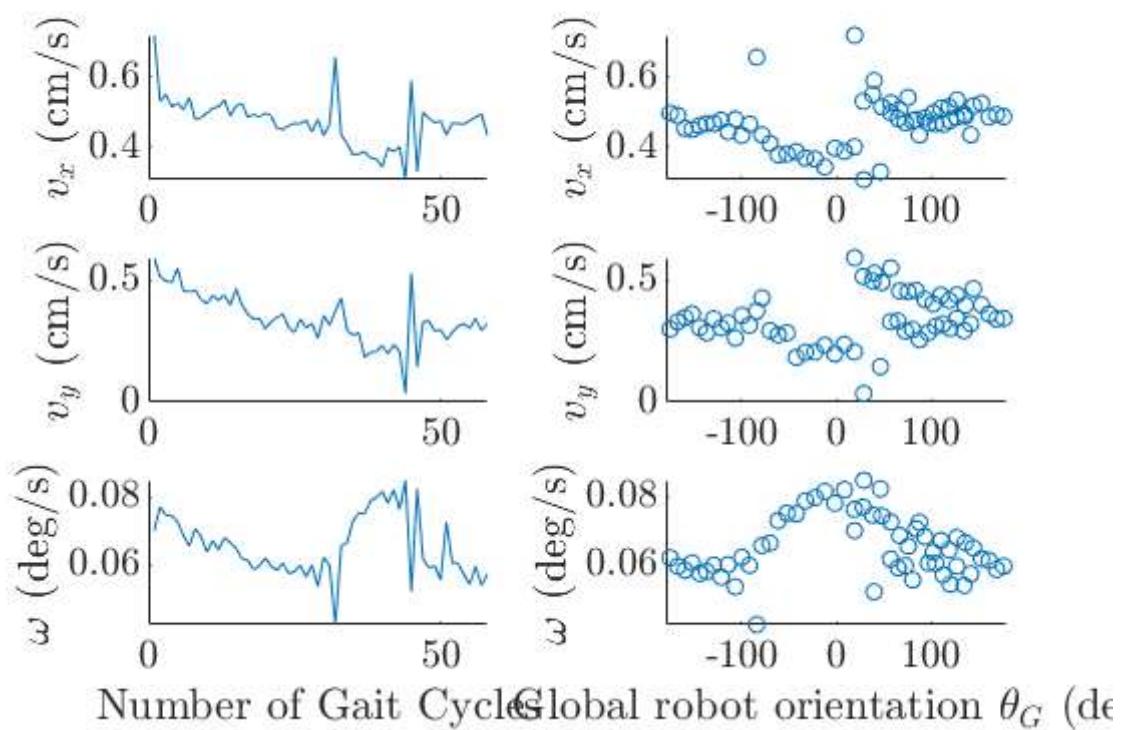
Radius of curvature



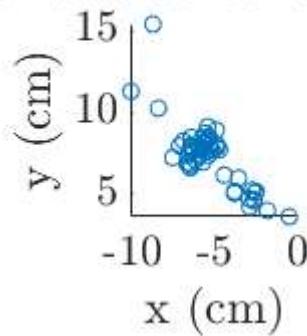
Experiment 24 : 60 cycles of Gait B with no sheath tether (left , not following), trial 1



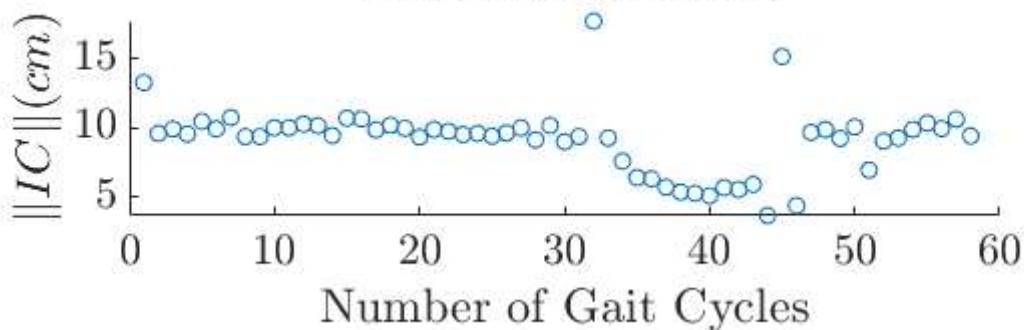
○ Gait B



Instantaneous center of rotation IC

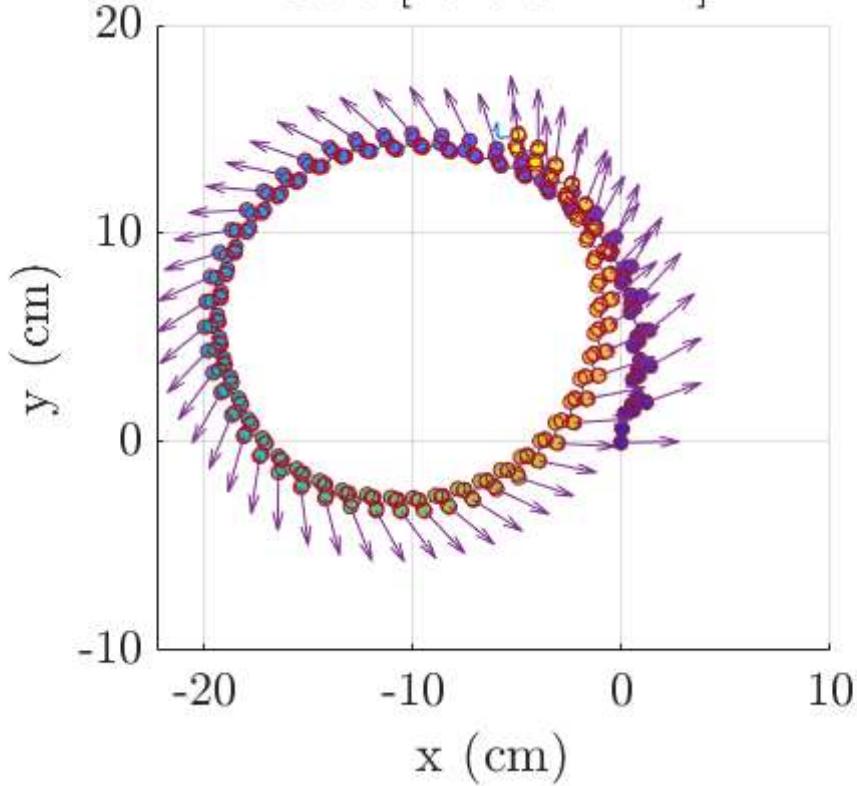


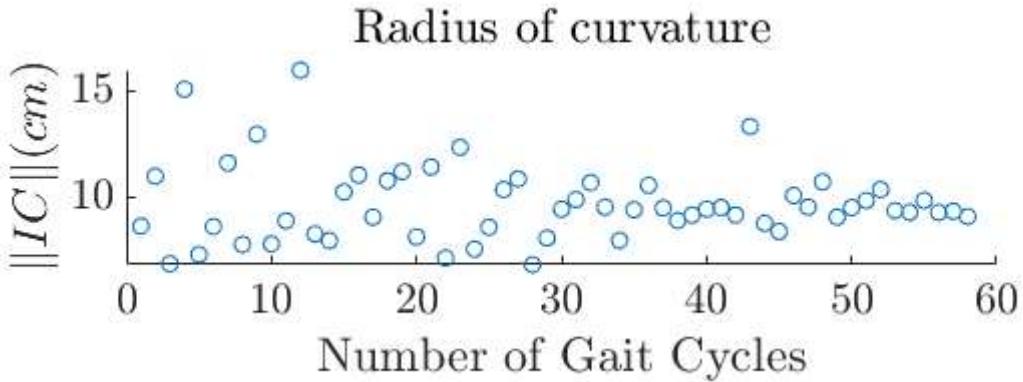
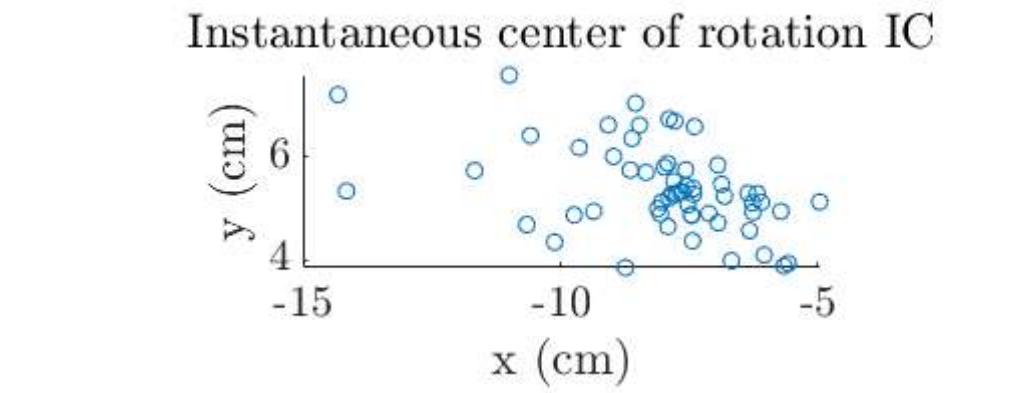
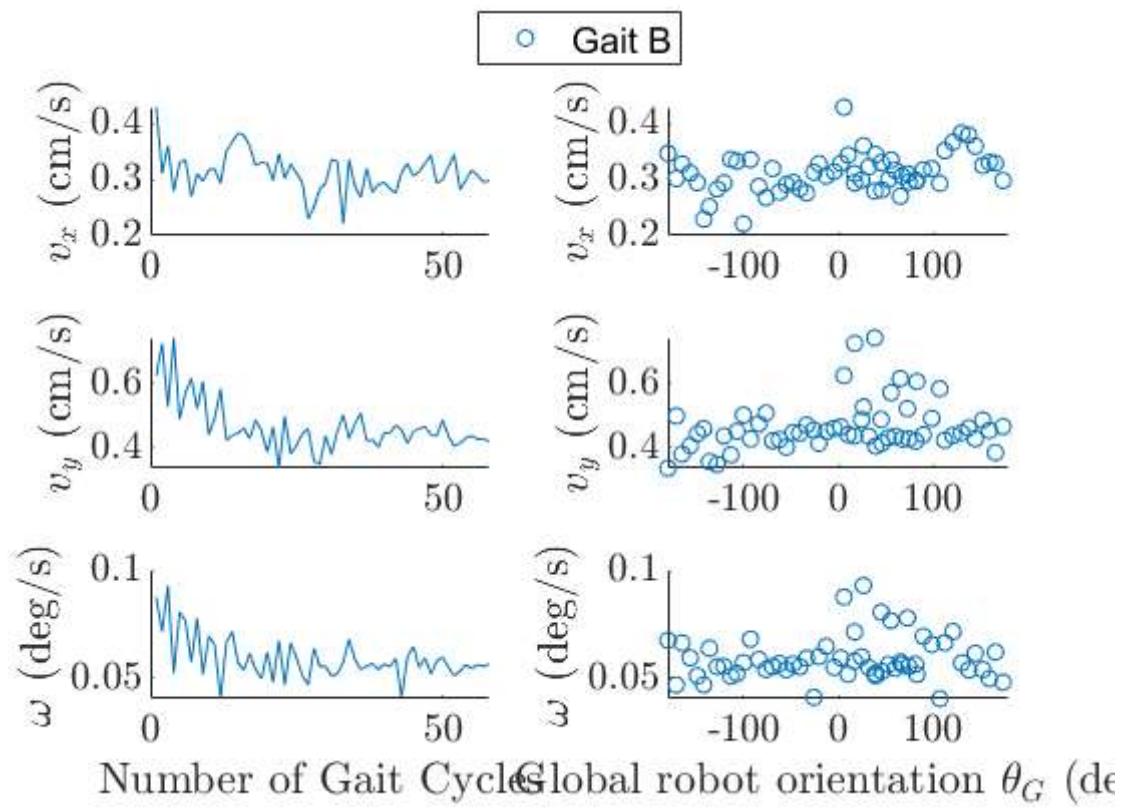
Radius of curvature



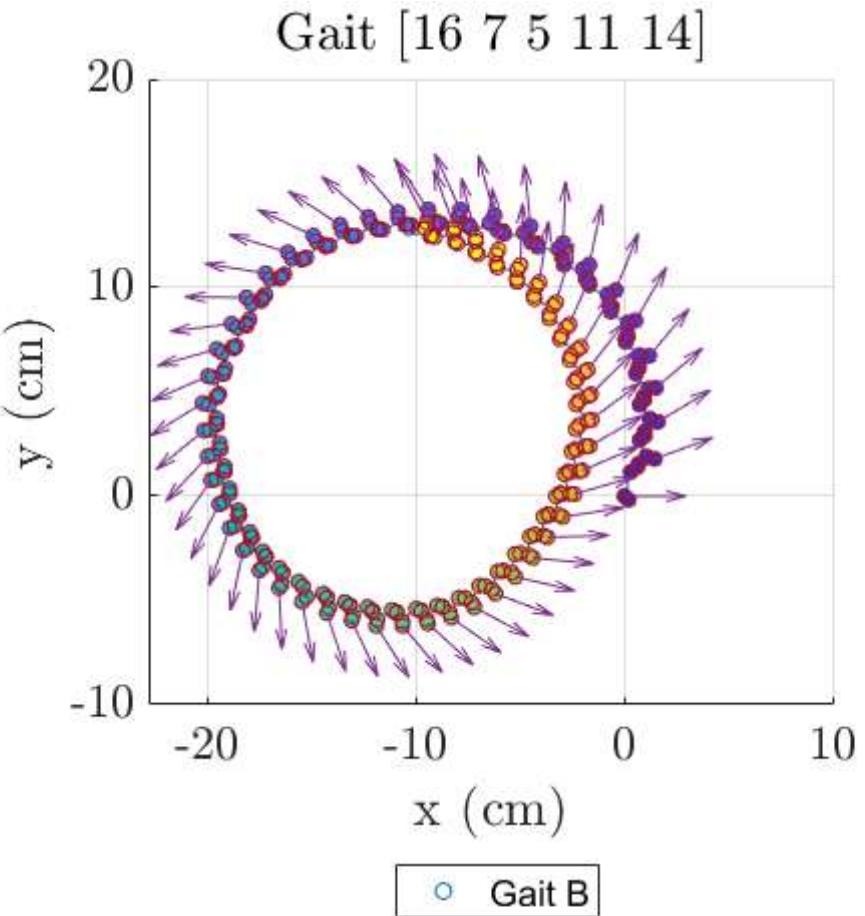
Experiment 25 : 60 cycles of Gait B with no sheath tether (left , not following), trial 2

Gait [16 7 5 11 14]

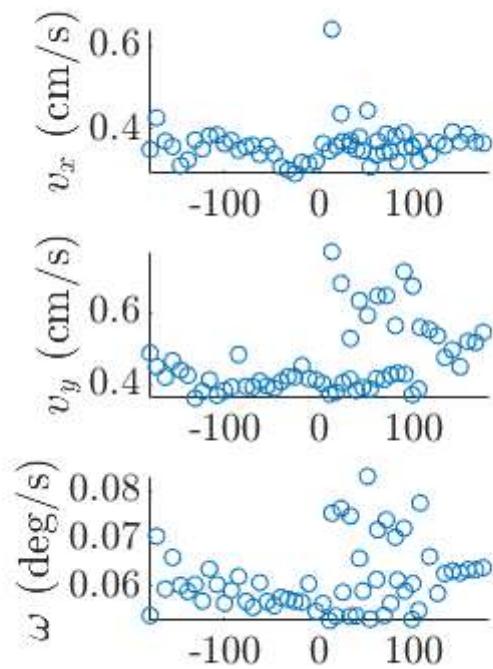
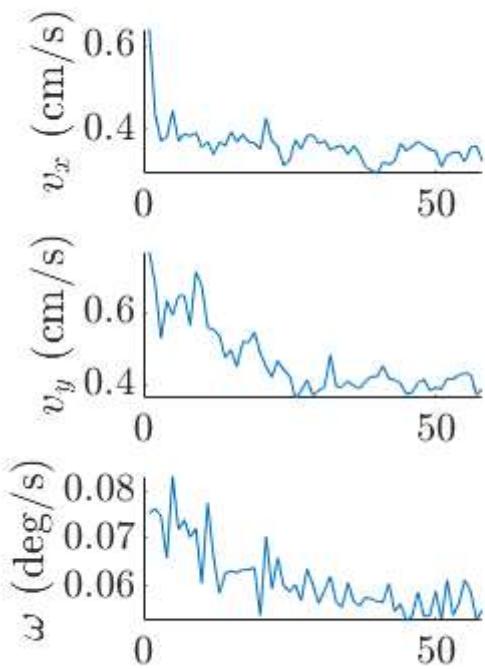




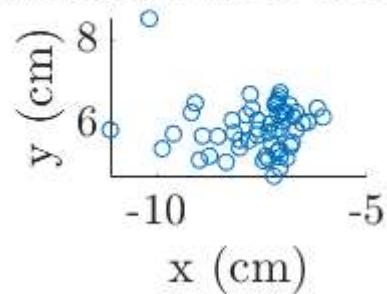
Experiment 26 : 60 cycles of Gait B with light sheath tether (right , following), trial 1



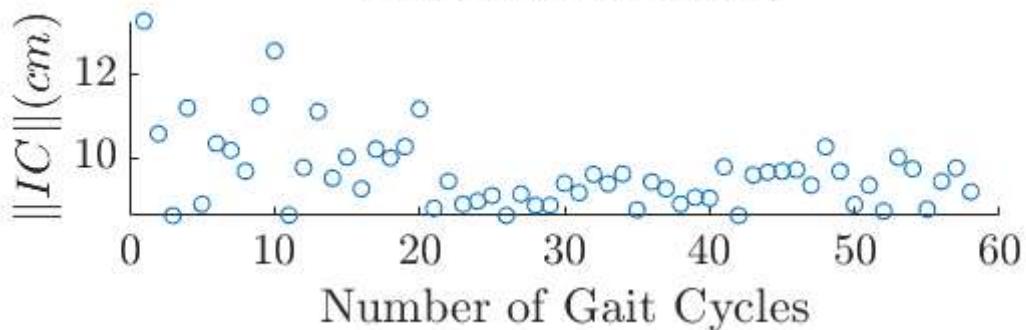
○ Gait B



Instantaneous center of rotation IC

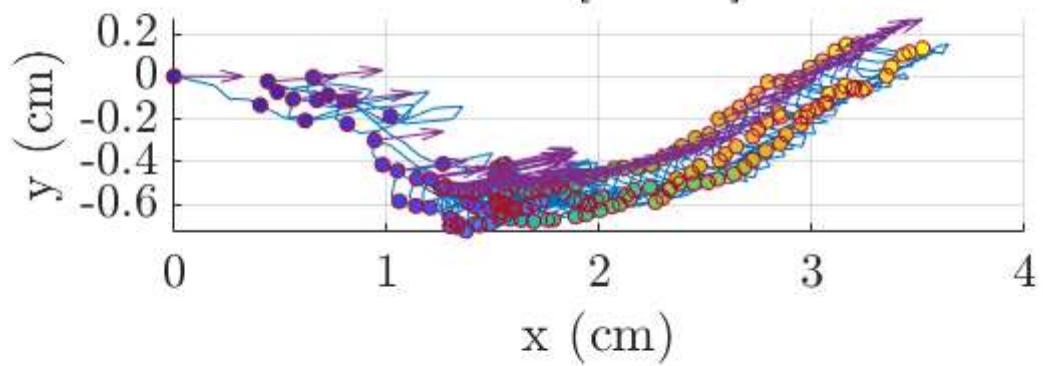


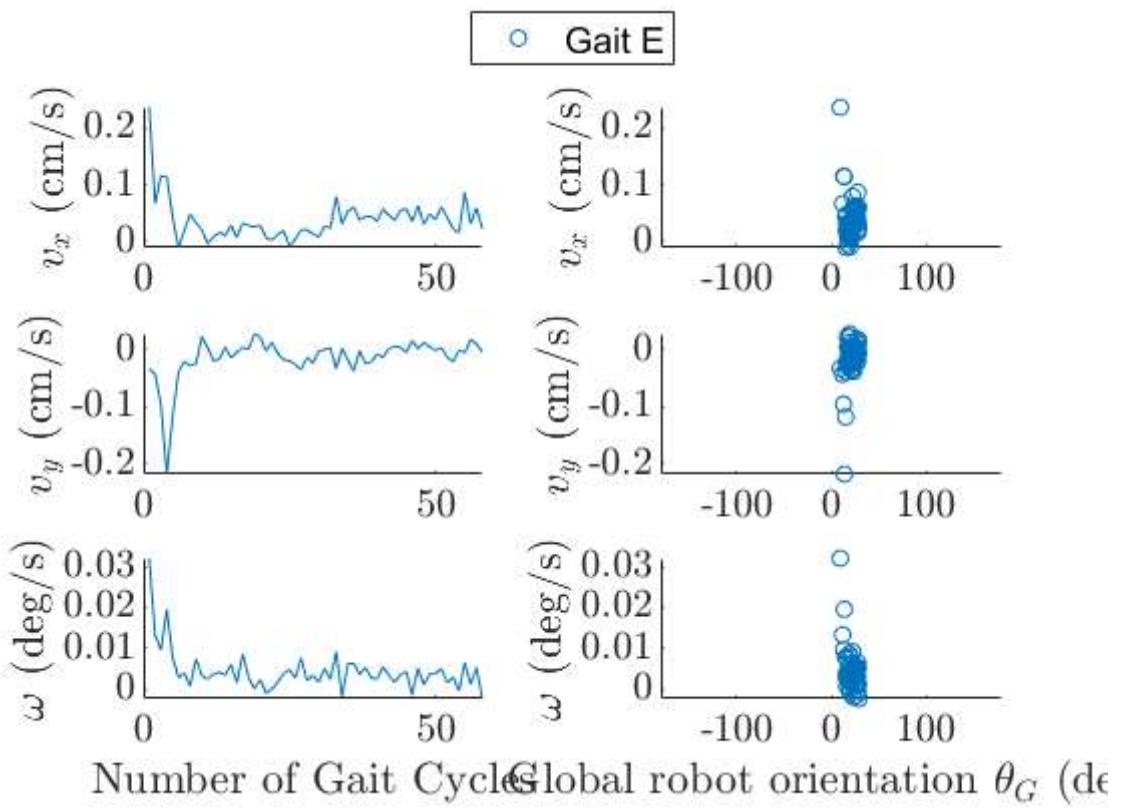
Radius of curvature



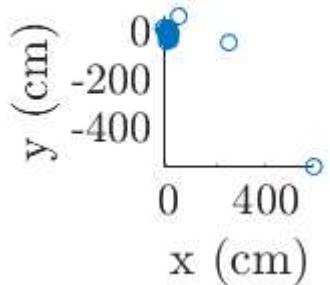
Experiment 27 : 60 cycles of Gait E with no sheath tether (right , not following), trial 1

Gait [9 16 1]

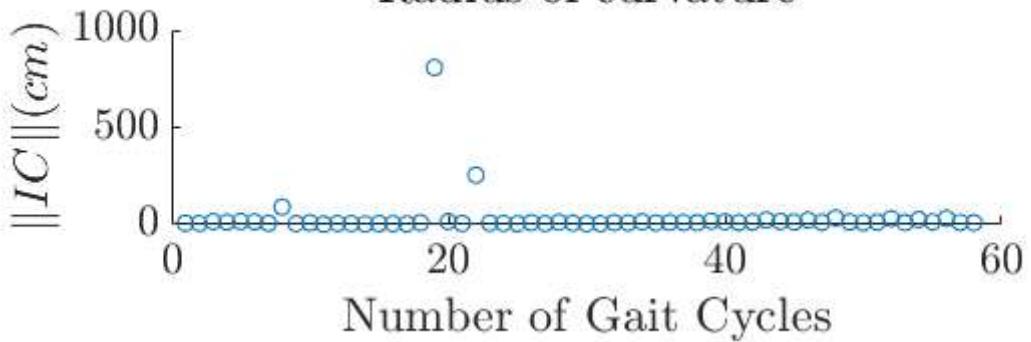




Instantaneous center of rotation IC

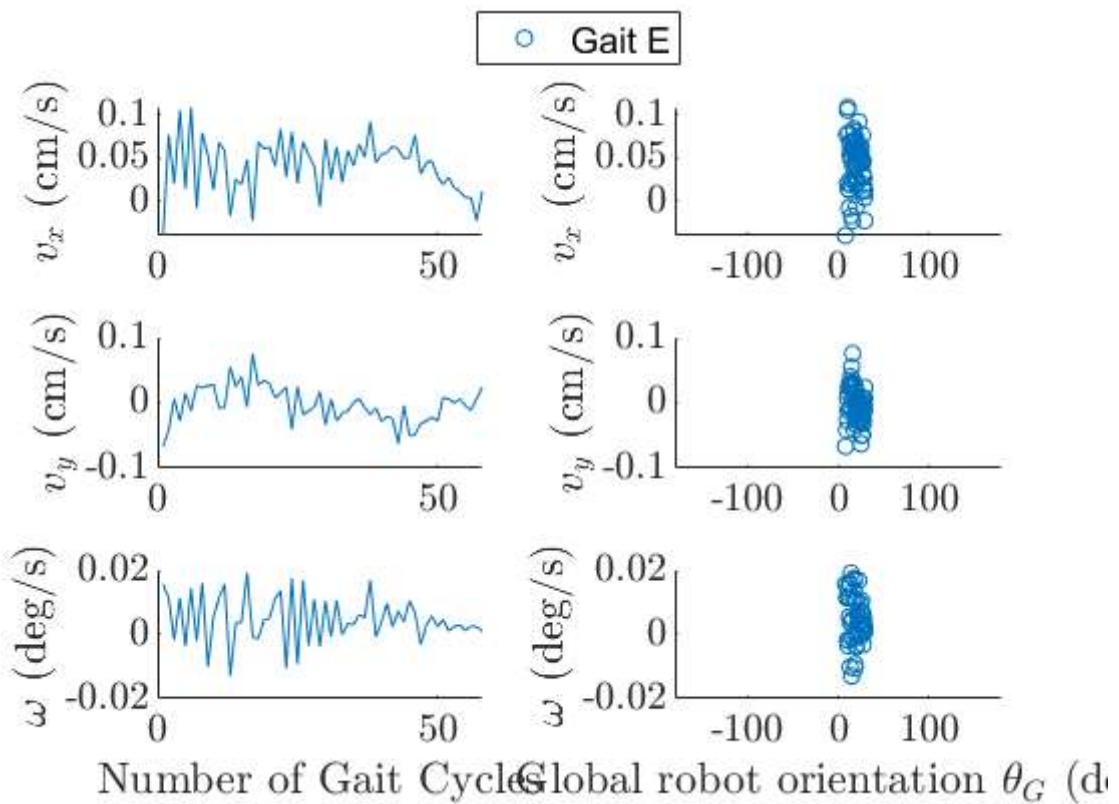
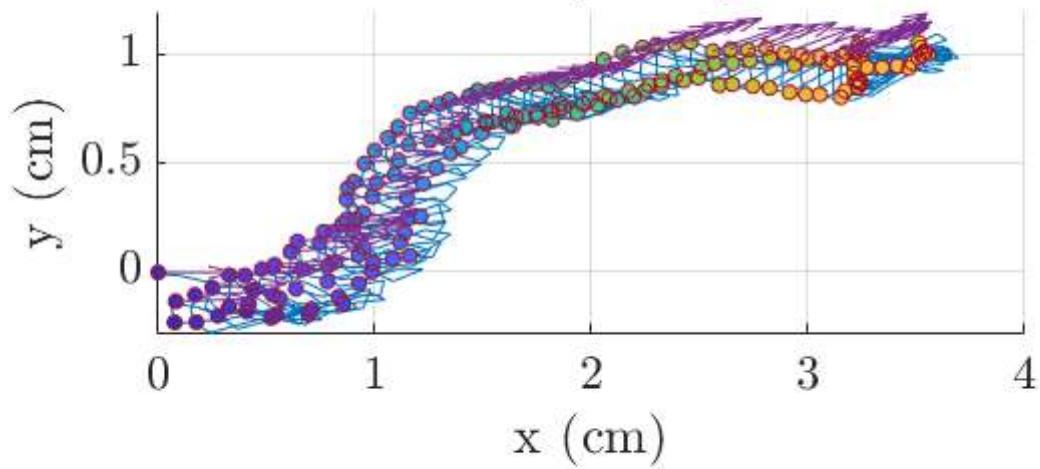


Radius of curvature

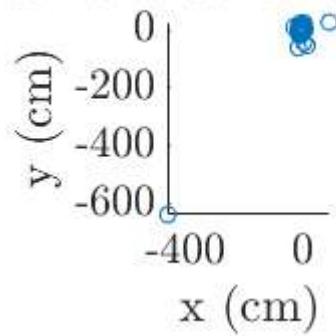


Experiment 28 : 60 cycles of Gait E with no sheath tether (right , not following), trial 2

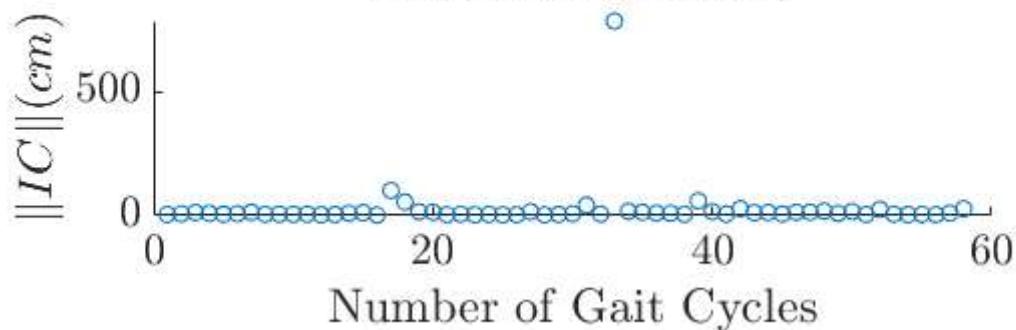
Gait [9 16 1]



Instantaneous center of rotation IC

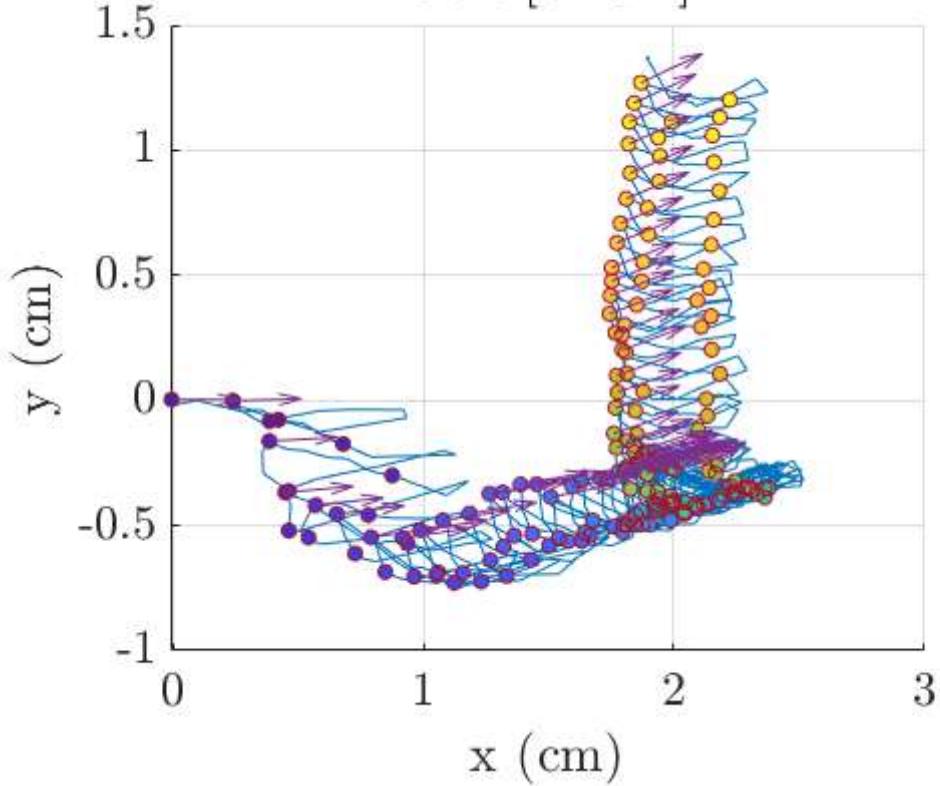


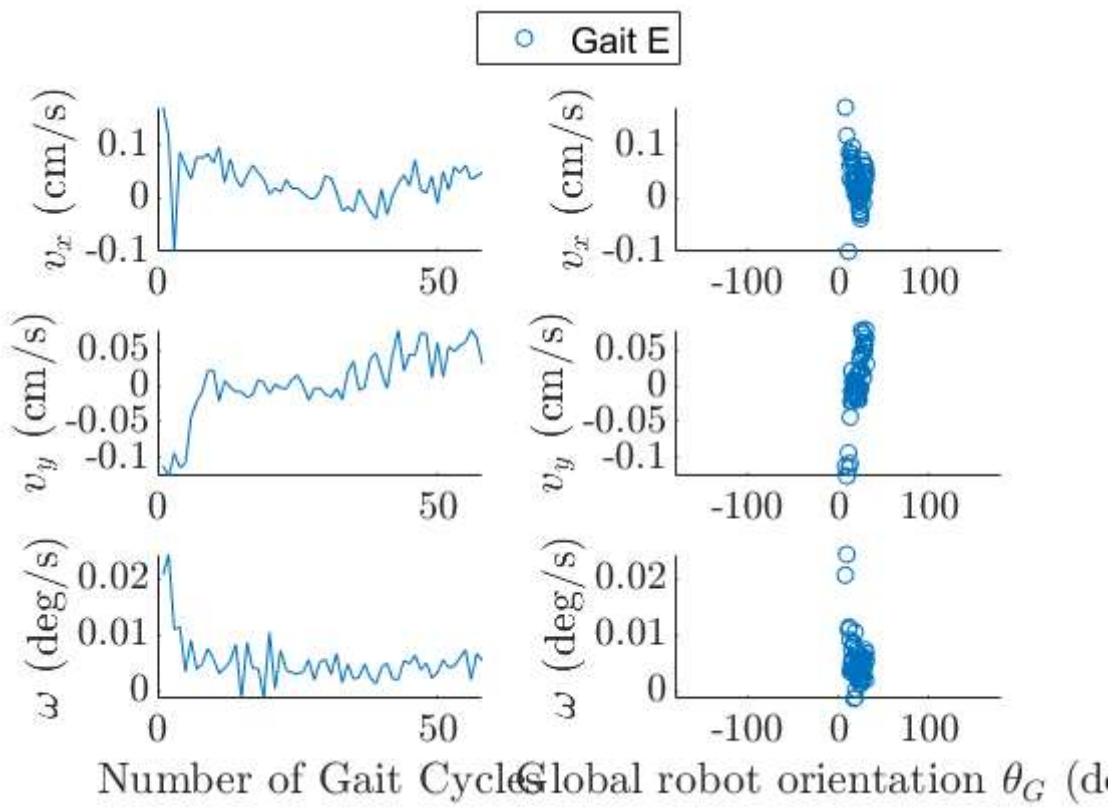
Radius of curvature



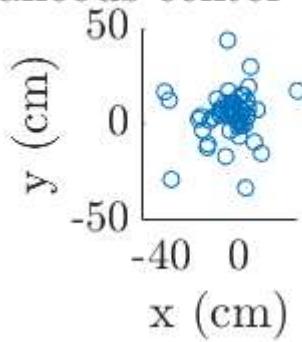
Experiment 29 : 60 cycles of Gait E with no sheath tether (left , not following), trial 2

Gait [9 16 1]

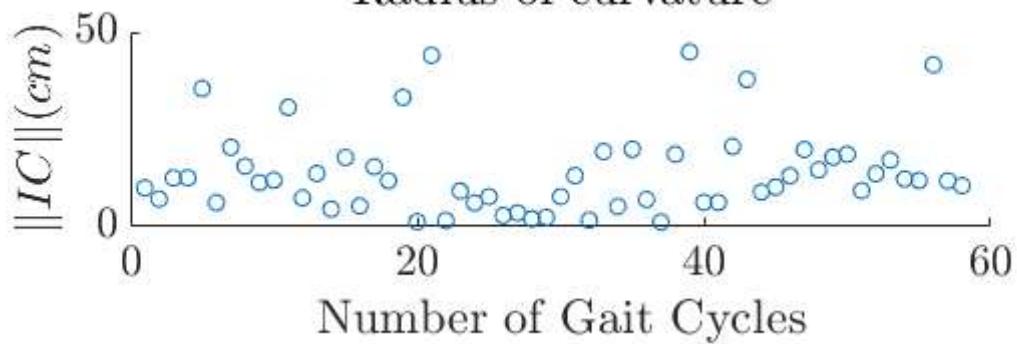




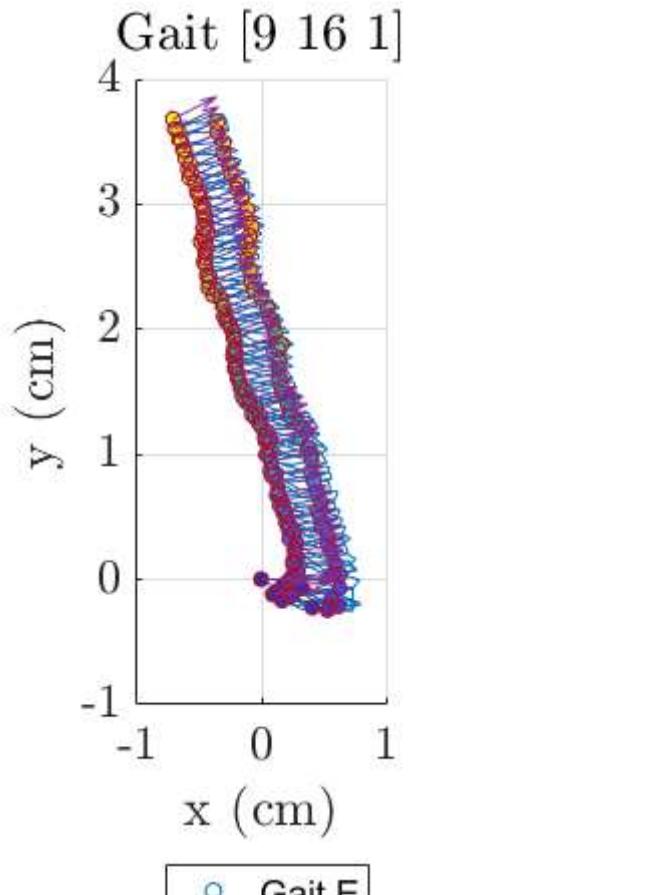
Instantaneous center of rotation IC



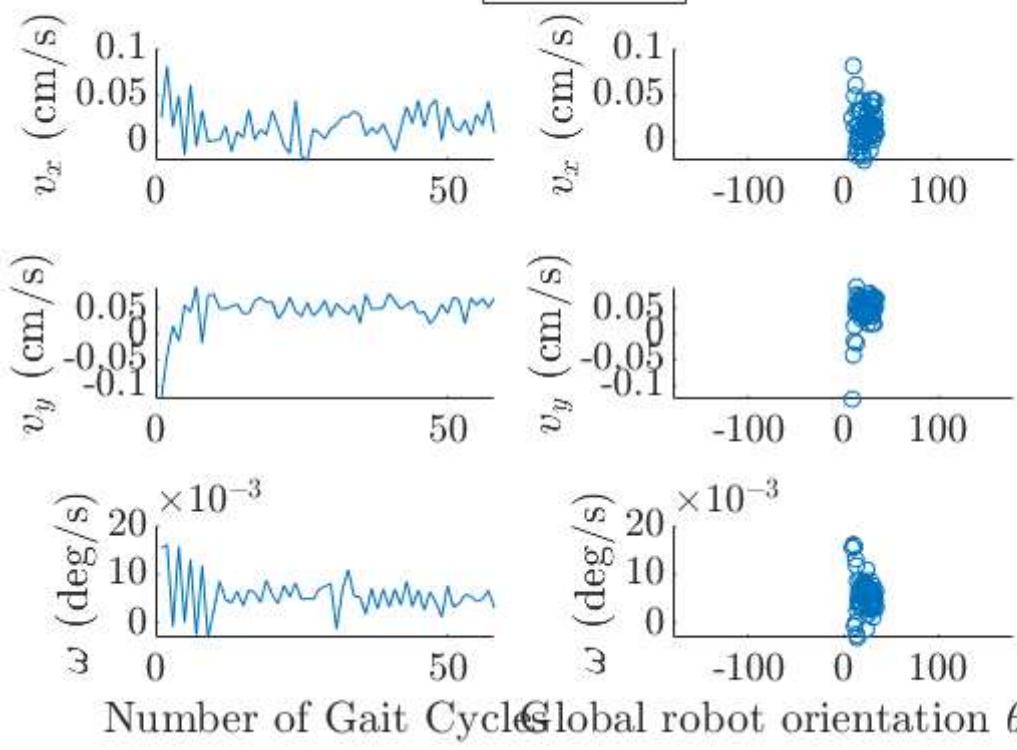
Radius of curvature



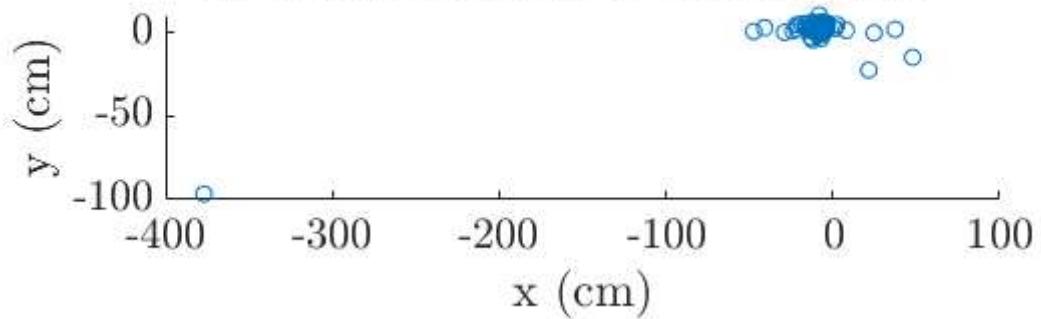
Experiment 30 : 60 cycles of Gait E with no sheath tether (left , not following), trial 3



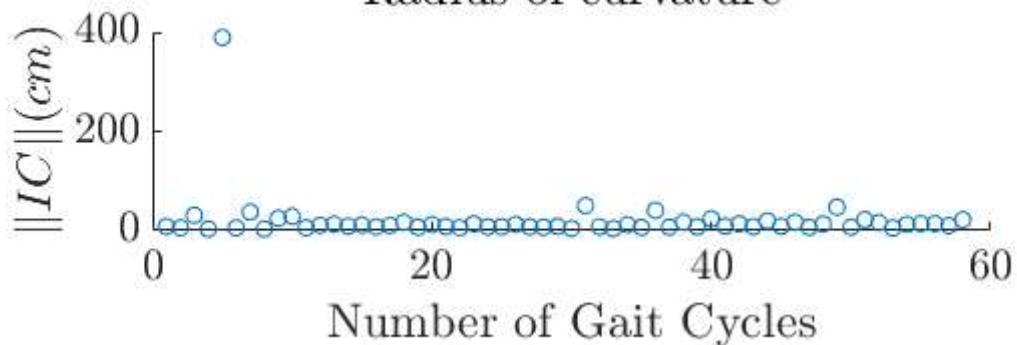
○ Gait E



Instantaneous center of rotation IC

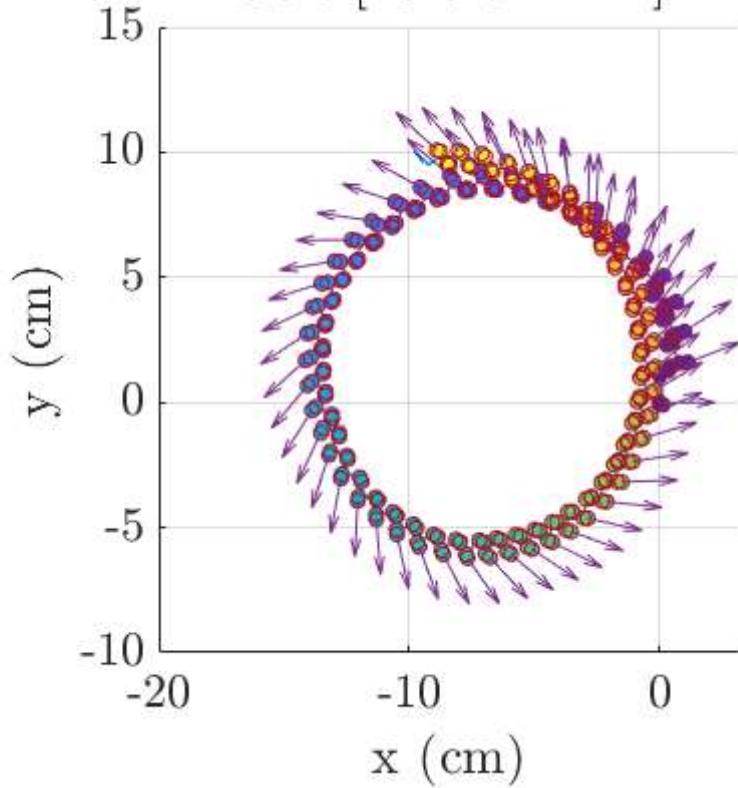


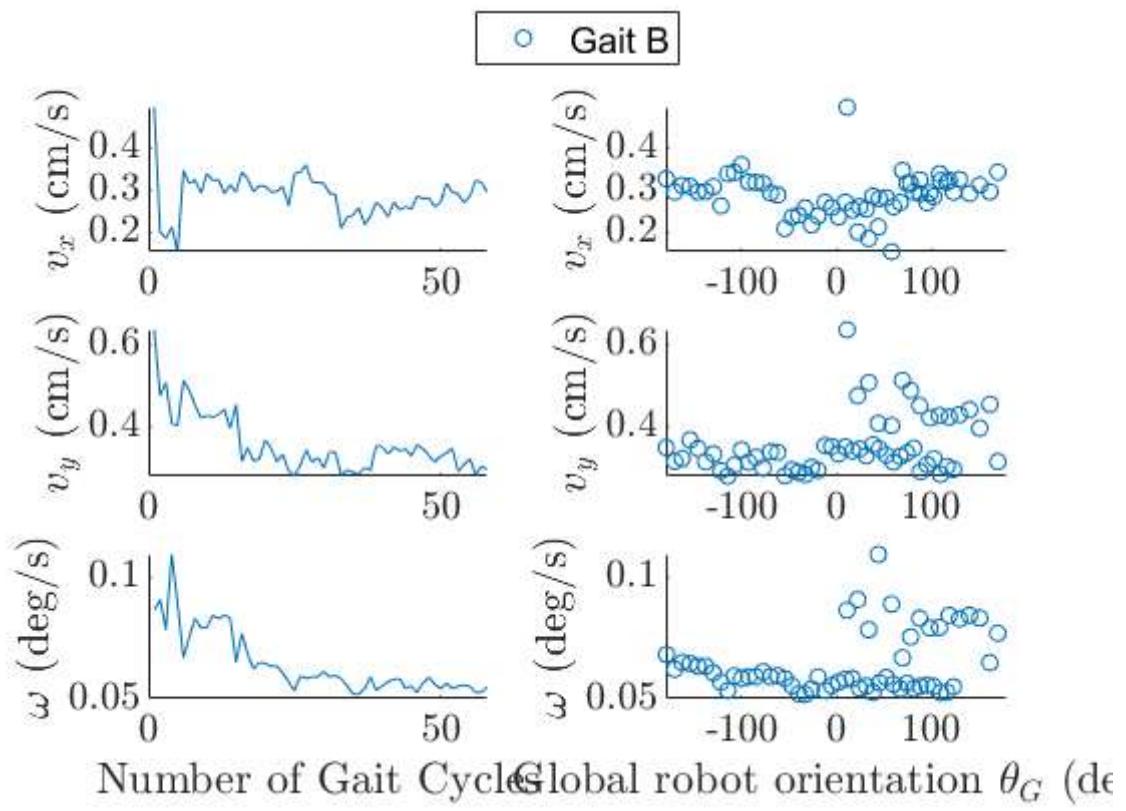
Radius of curvature



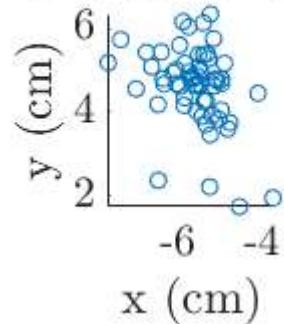
Experiment 31 : 60 cycles of Gait B with 32 AWG tether (left , not following), trial 1

Gait [16 7 5 11 14]

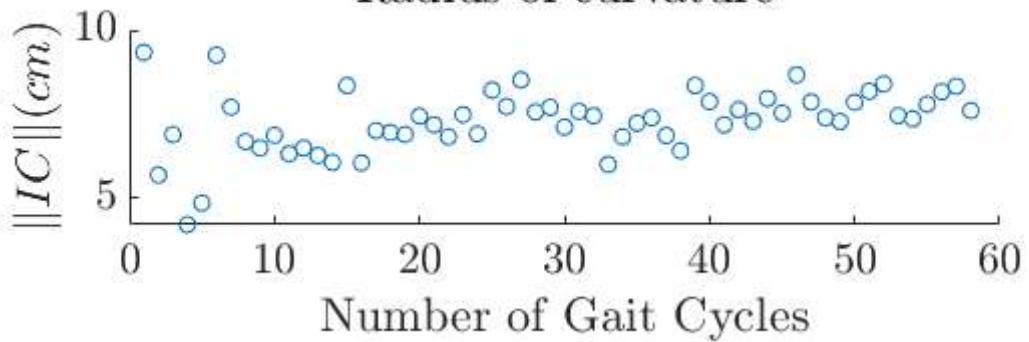




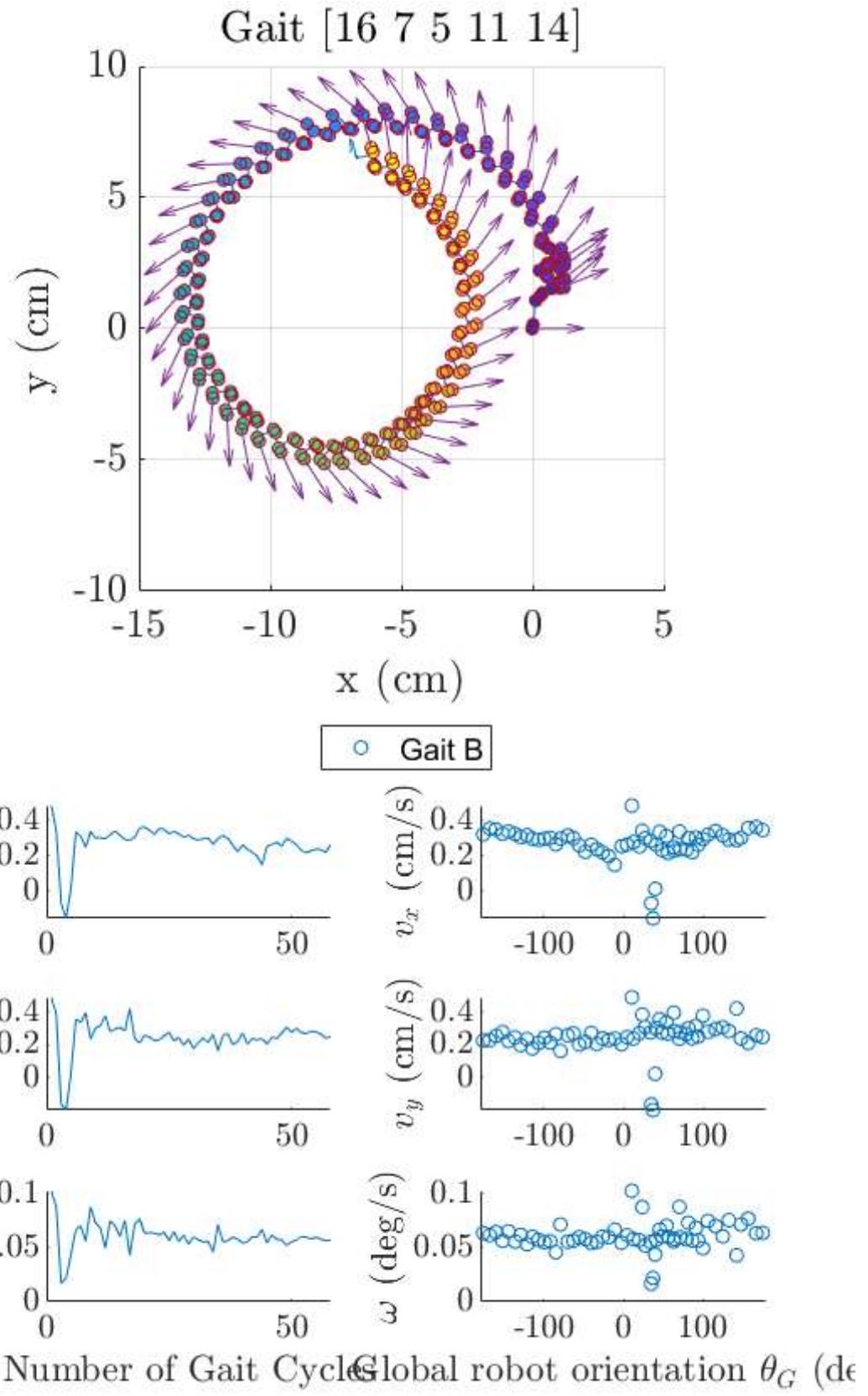
Instantaneous center of rotation IC



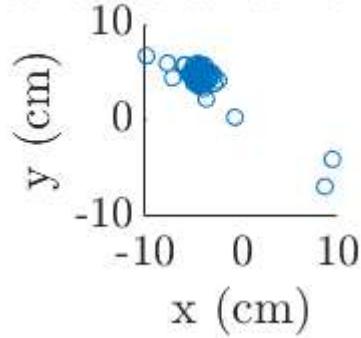
Radius of curvature



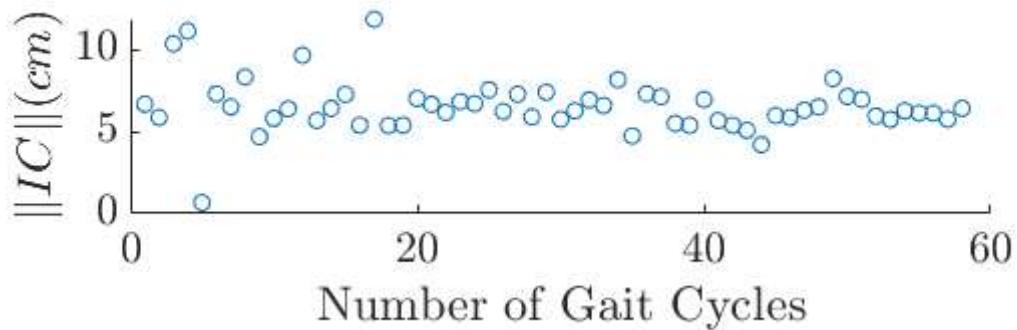
Experiment 32 : 60 cycles of Gait B with 32 AWG tether (left , not following), trial 2



Instantaneous center of rotation IC

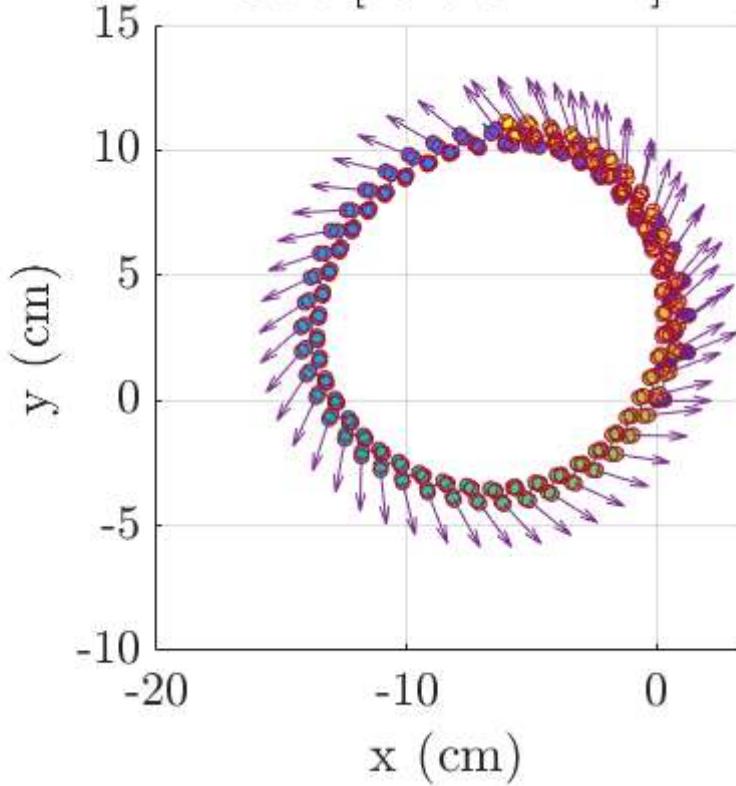


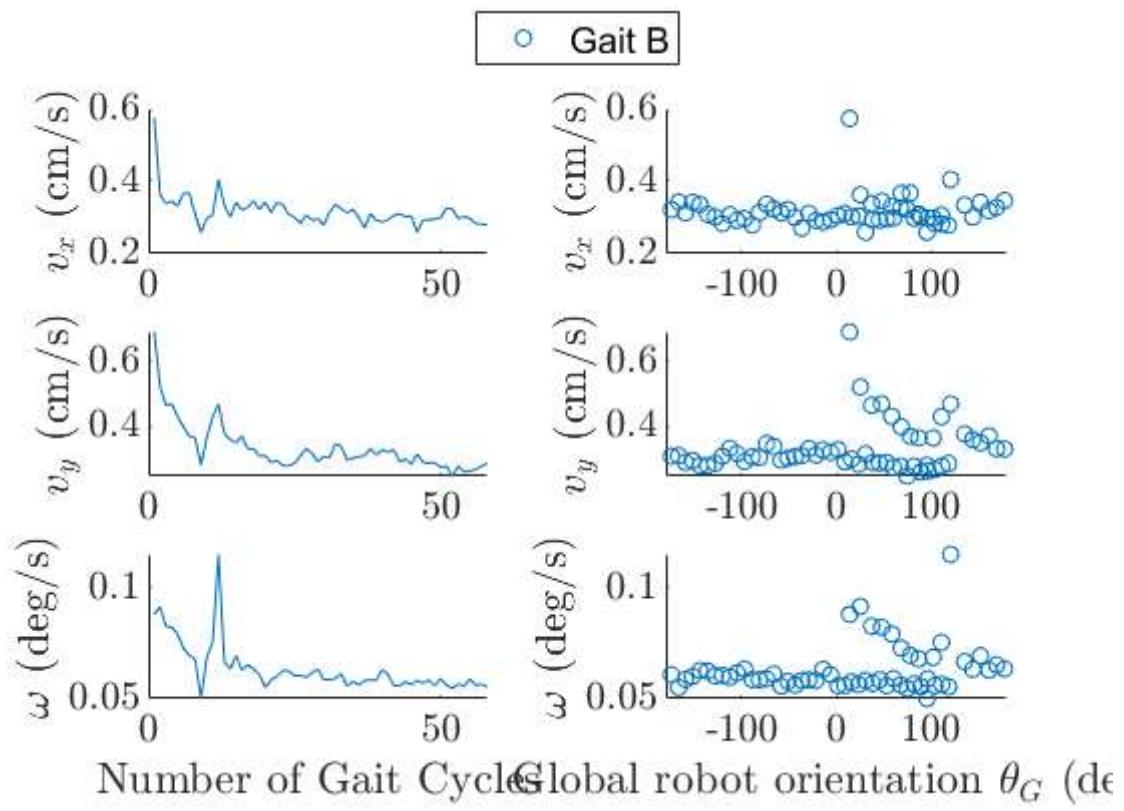
Radius of curvature



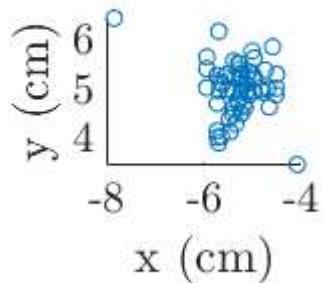
Experiment 33 : 60 cycles of Gait B with 32 AWG tether (right , not following), trial 1

Gait [16 7 5 11 14]

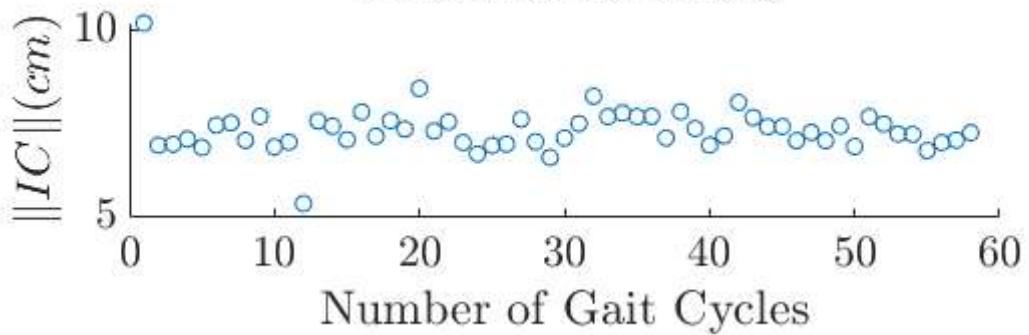




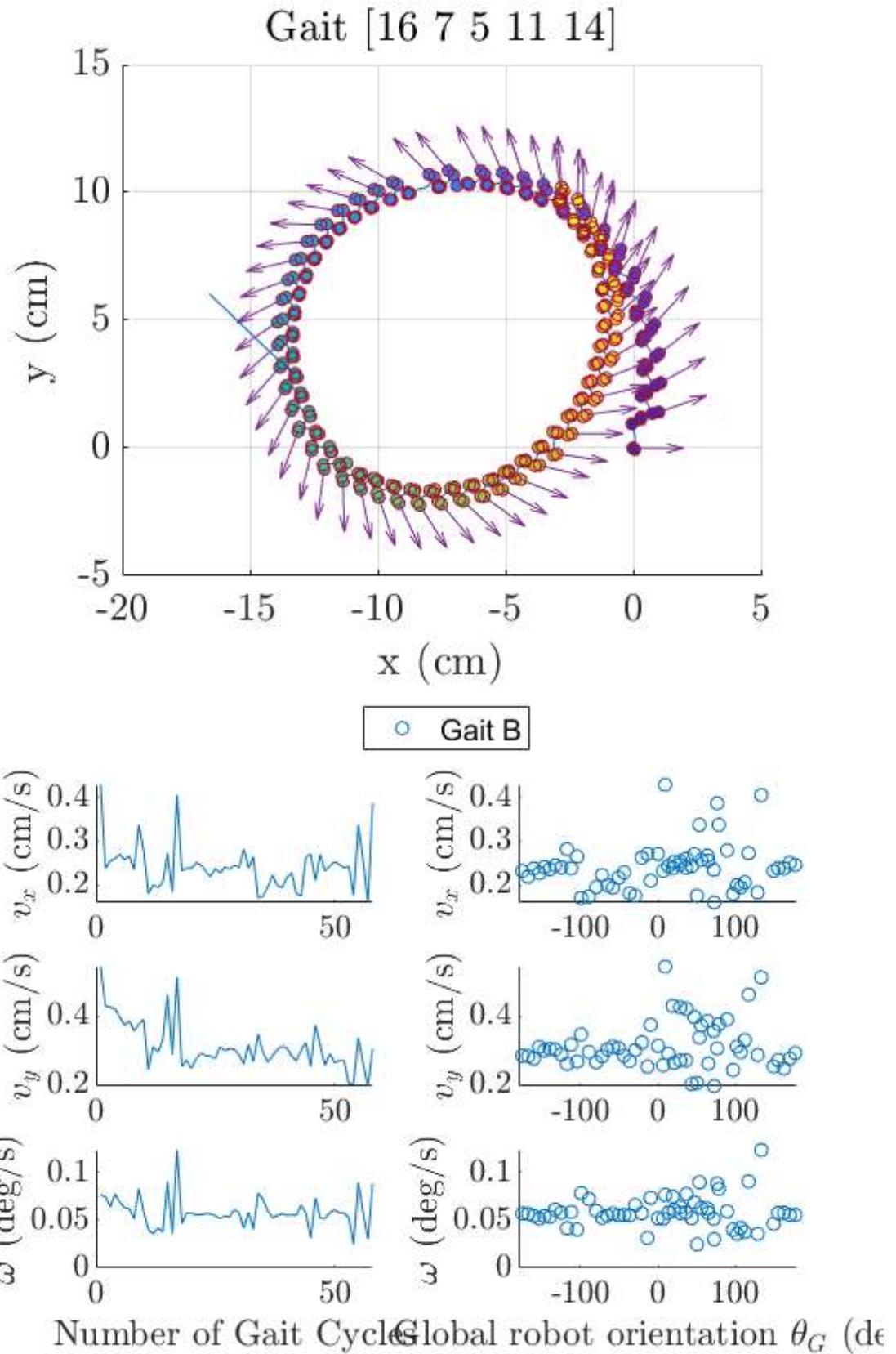
Instantaneous center of rotation IC



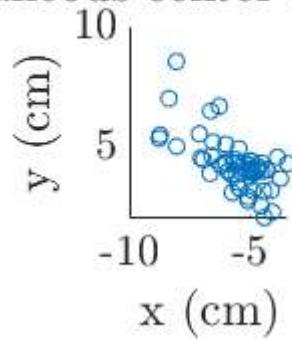
Radius of curvature



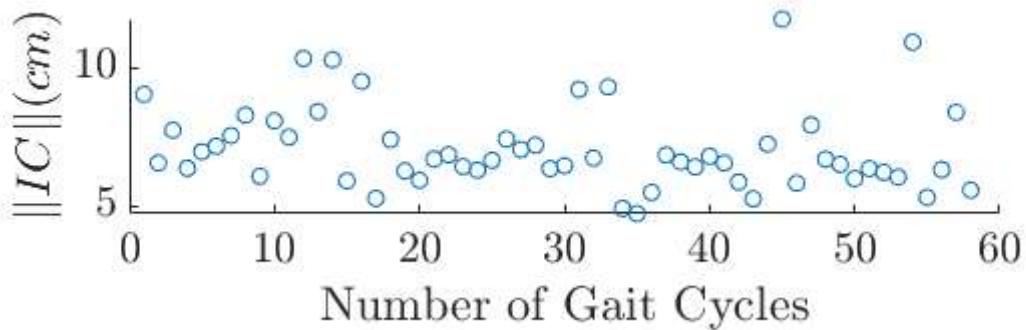
Experiment 34 : 60 cycles of Gait B with 32 AWG tether (right , not following), trial 2



Instantaneous center of rotation IC

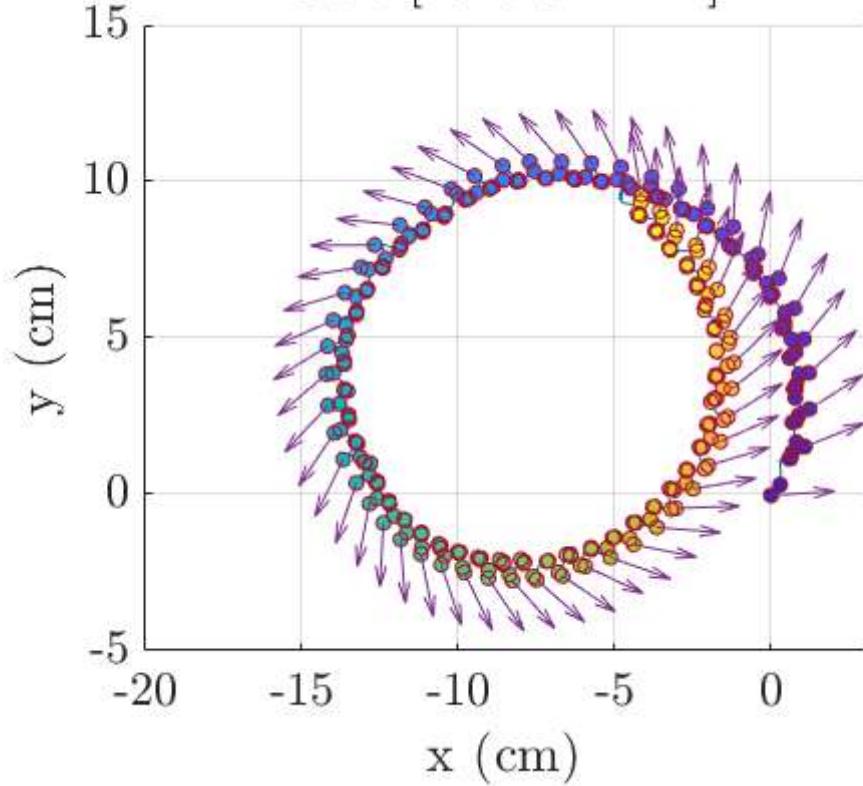


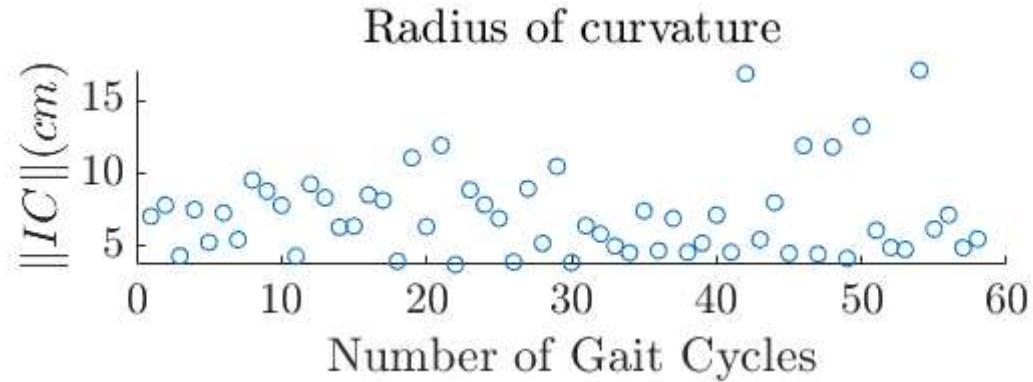
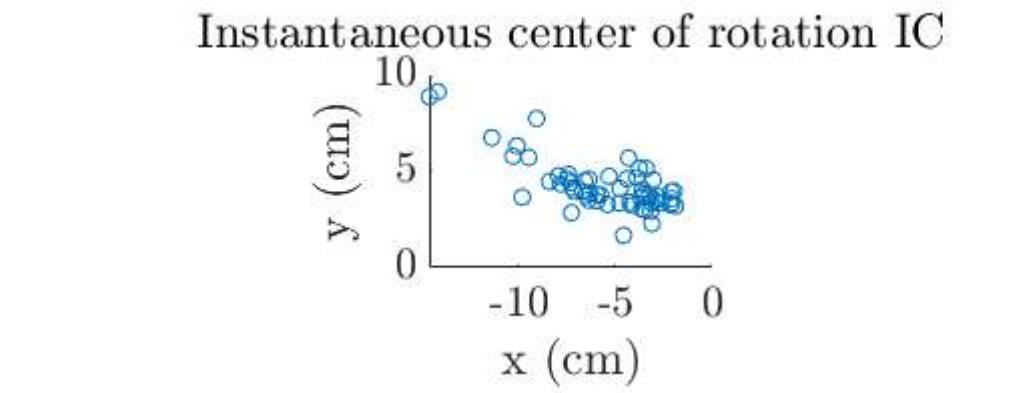
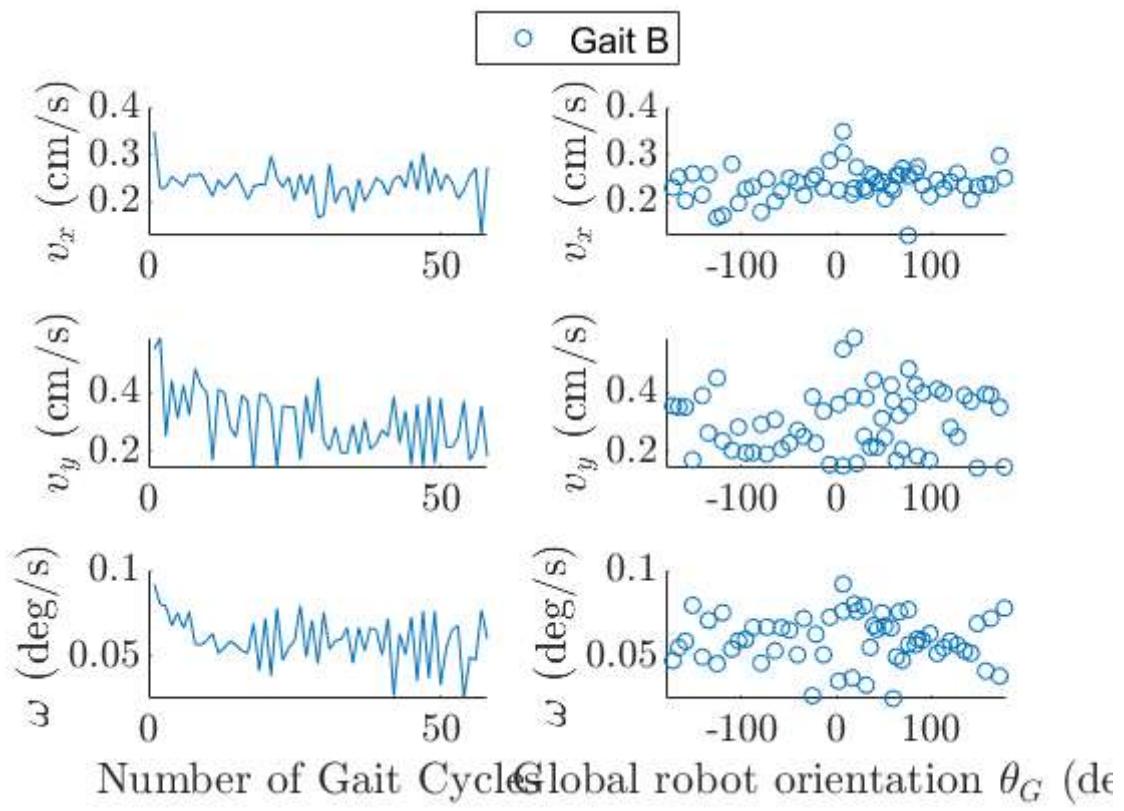
Radius of curvature



Experiment 35 : 60 cycles of Gait B with 32 AWG with old slip ring tether (right , not following

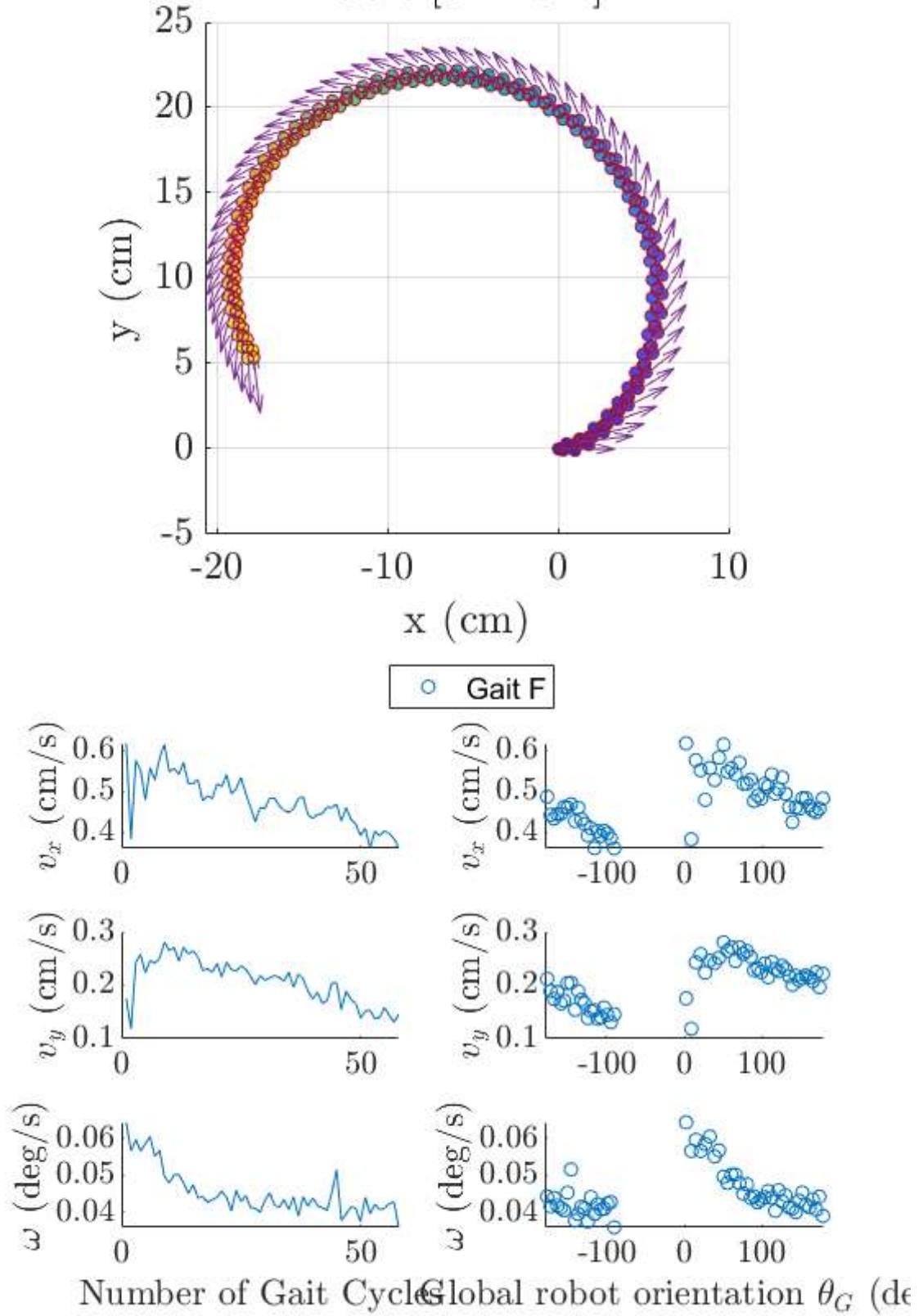
Gait [16 7 5 11 14]



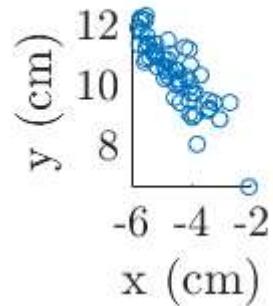


Experiment 36 : 60 cycles of Gait F with 32 AWG with slip ring tether (left , not following), tr

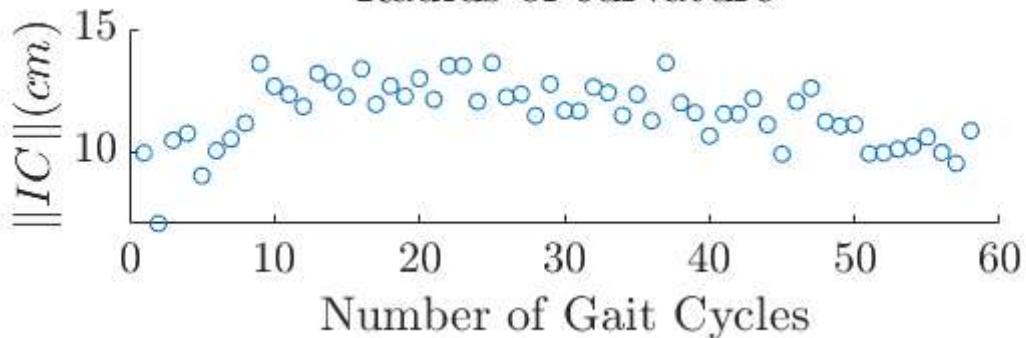
Gait [9 14 8 1]



Instantaneous center of rotation IC

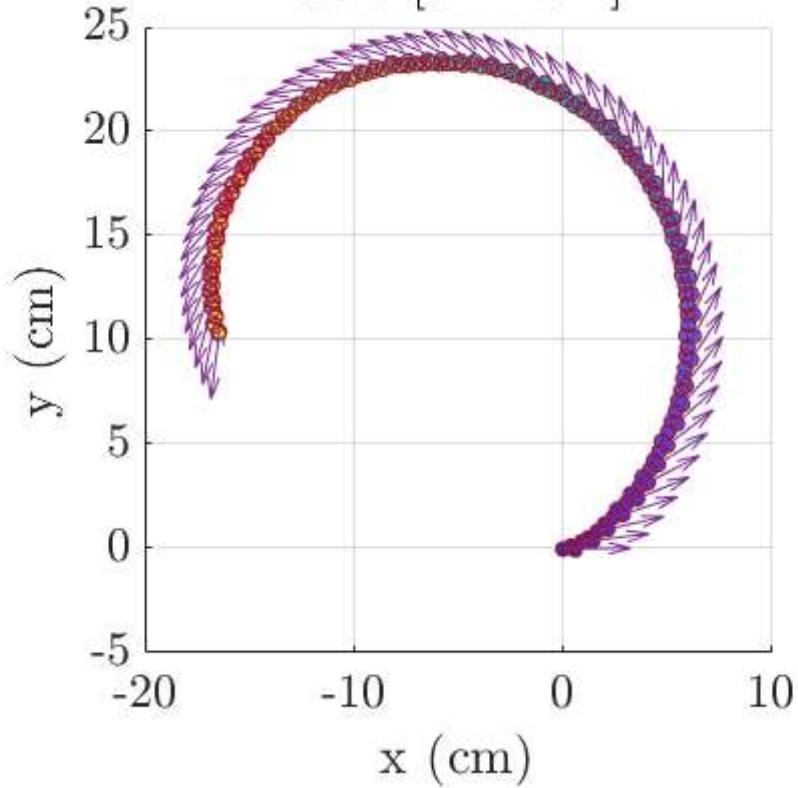


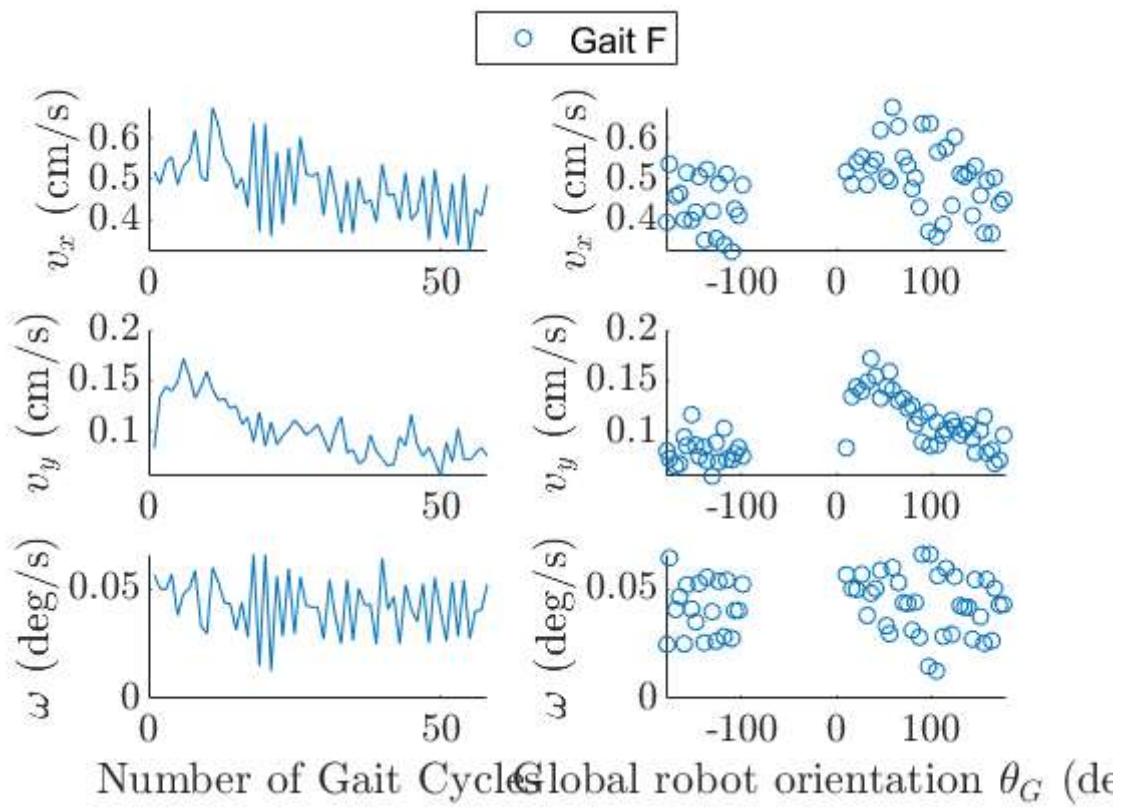
Radius of curvature



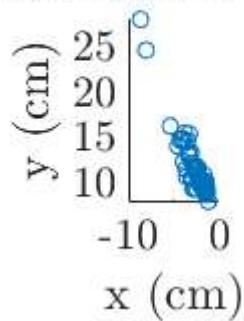
Experiment 37 : 60 cycles of Gait F with 32 AWG with slip ring tether (left , not following), tr

Gait [9 14 8 1]

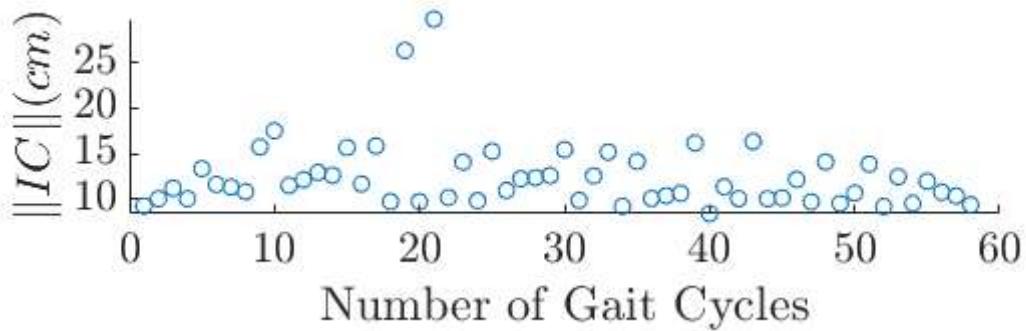




Instantaneous center of rotation IC

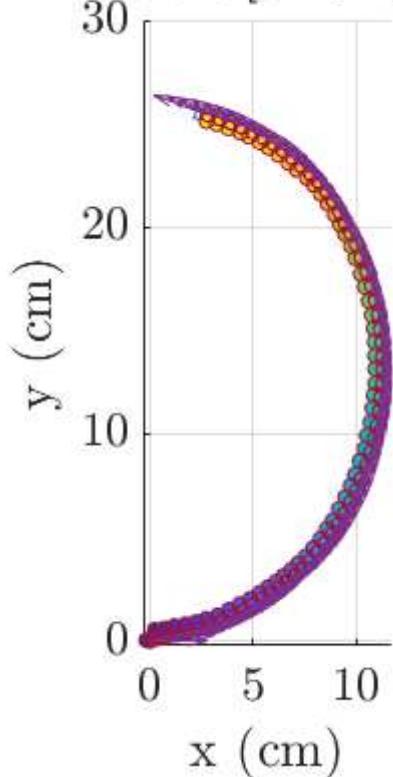


Radius of curvature

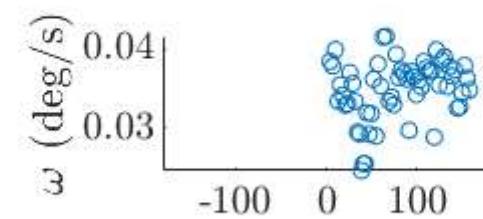
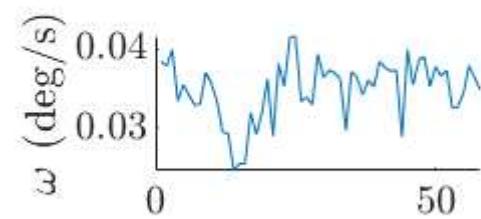
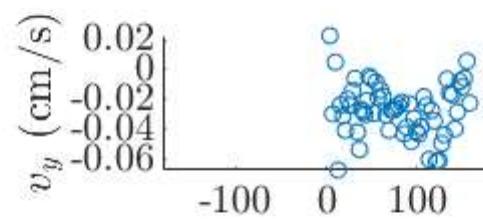
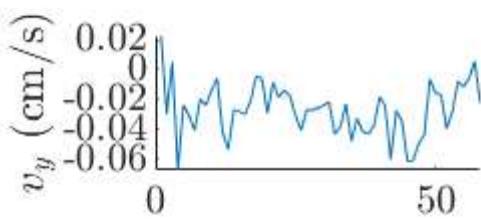
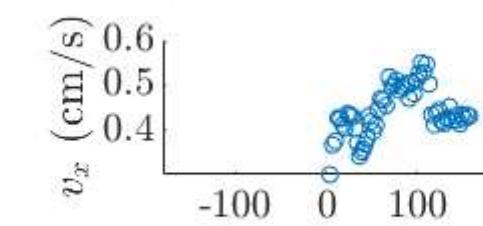
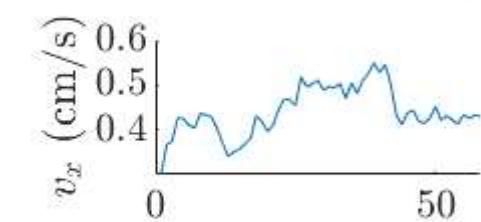


Experiment 38 : 60 cycles of Gait G with 32 AWG with slip ring tether (left , not following), tr

Gait [3 15 1]

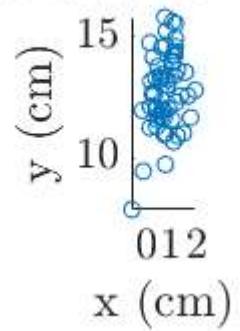


○ Gait G

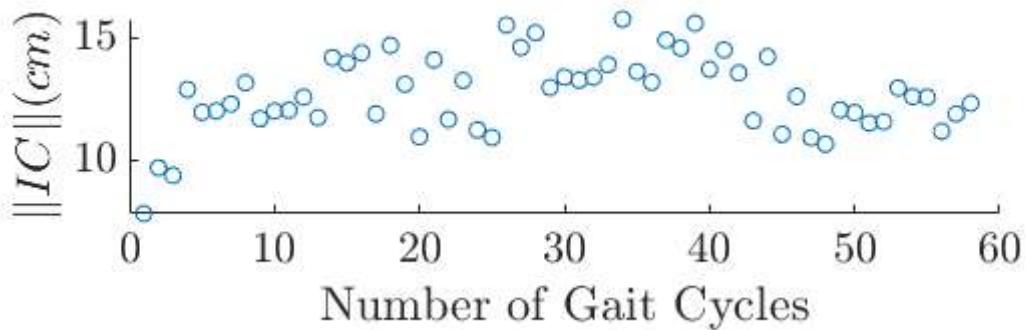


Number of Gait Cycles Global robot orientation θ_G (d)

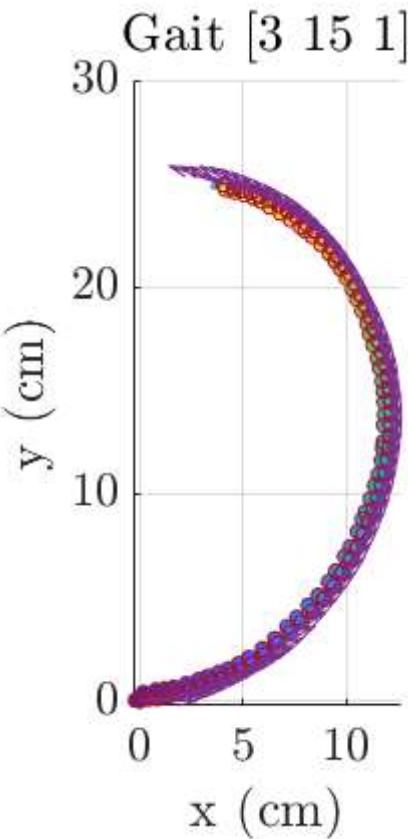
Instantaneous center of rotation IC

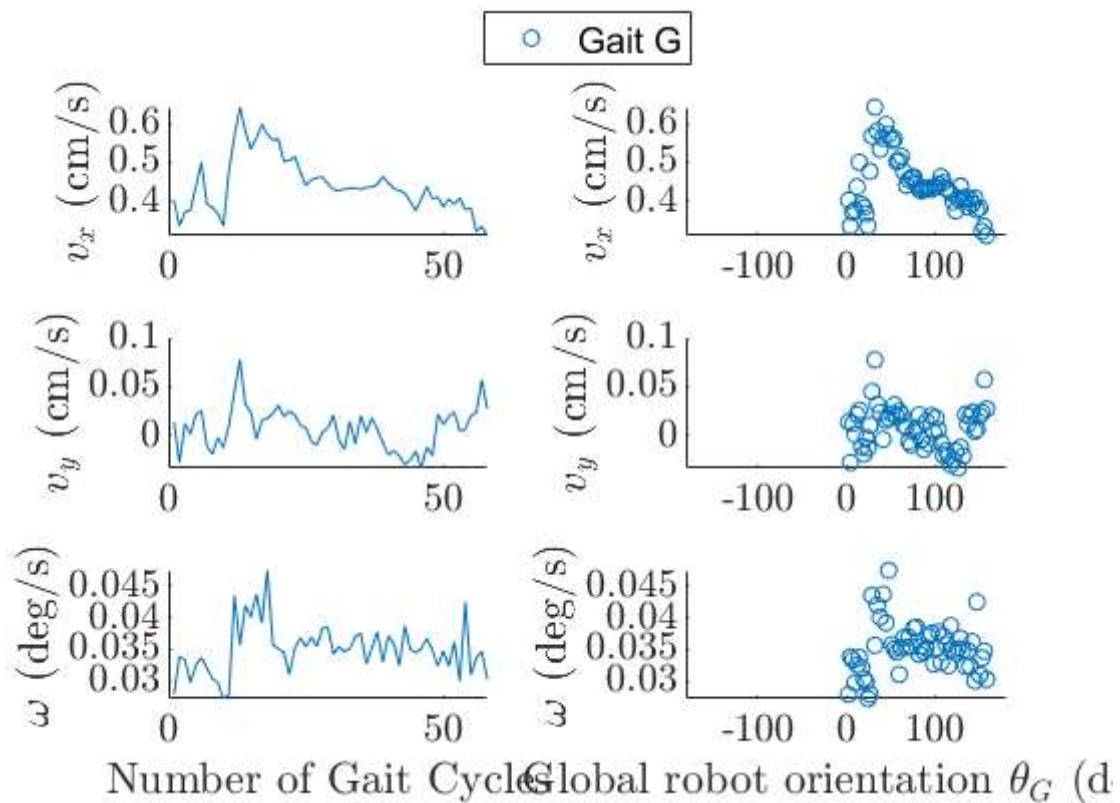


Radius of curvature

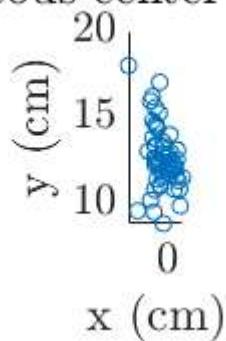


Experiment 39 : 60 cycles of Gait G with 32 AWG with slip ring tether (left , not following), tr

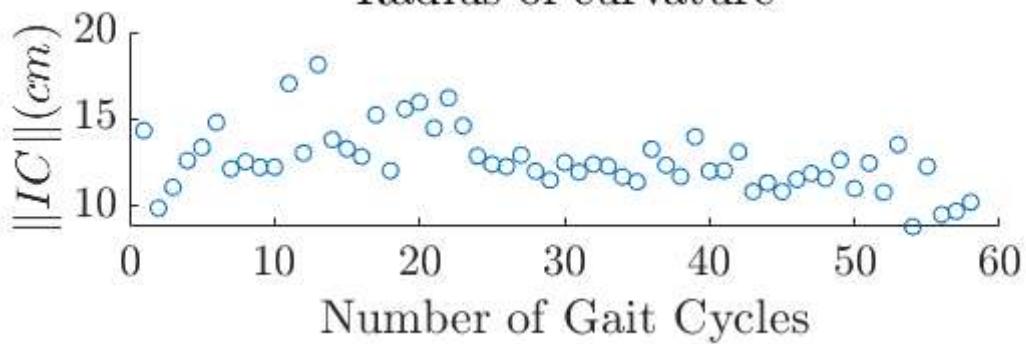




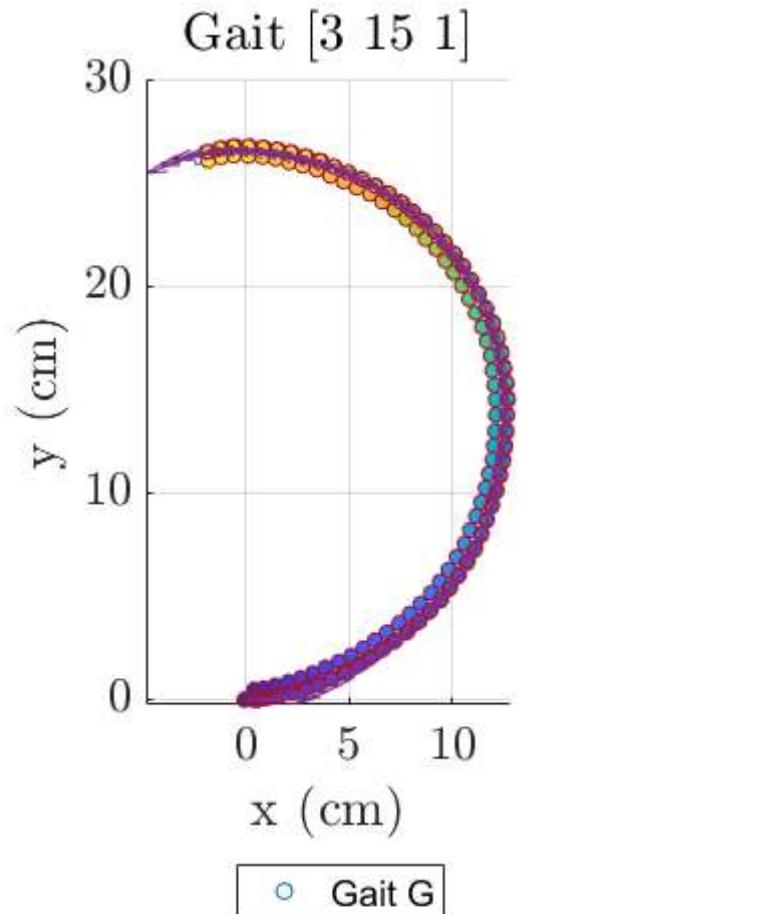
Instantaneous center of rotation IC



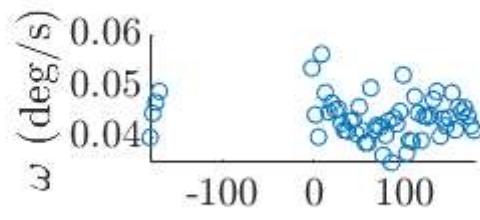
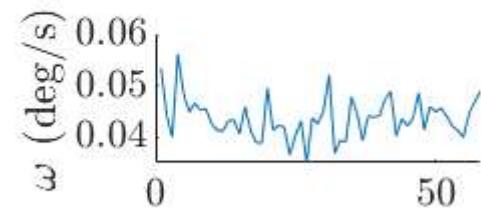
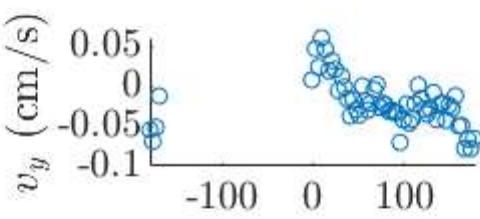
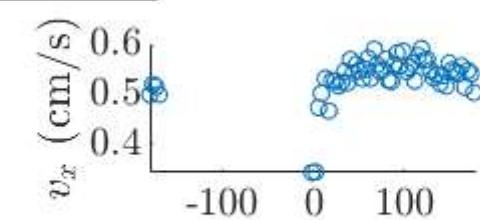
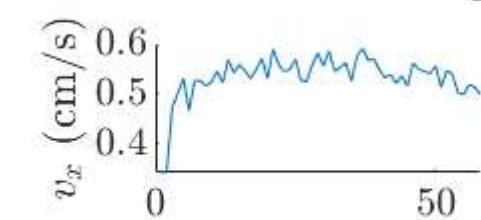
Radius of curvature



Experiment 40 : 60 cycles of Gait G with 32 AWG with slip ring tether (right , not following), t

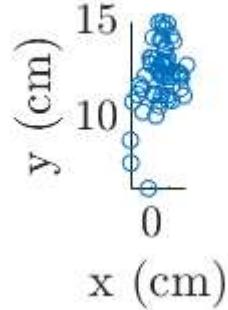


○ Gait G

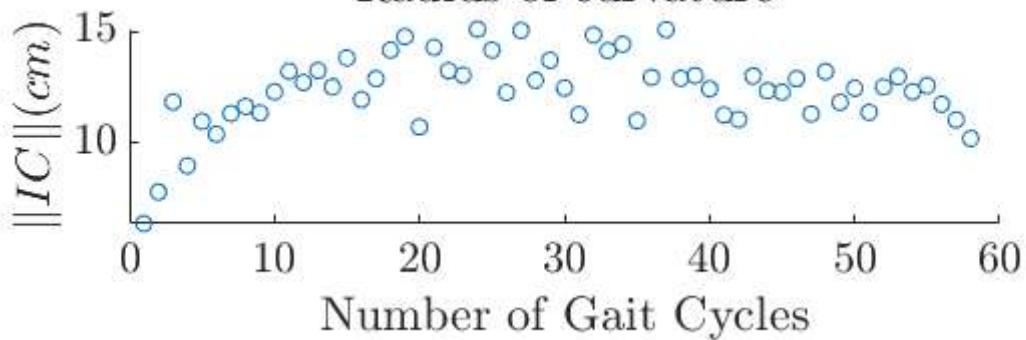


Number of Gait Cycles Global robot orientation θ_G (deg)

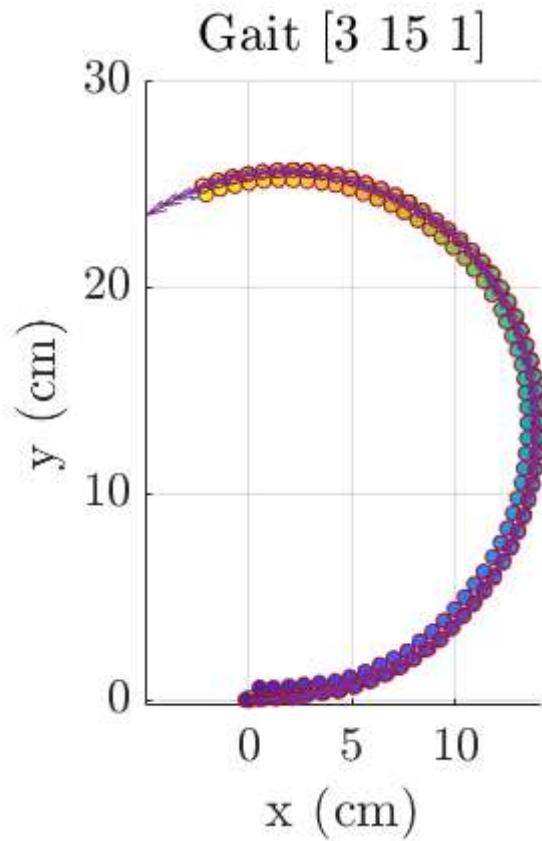
Instantaneous center of rotation IC

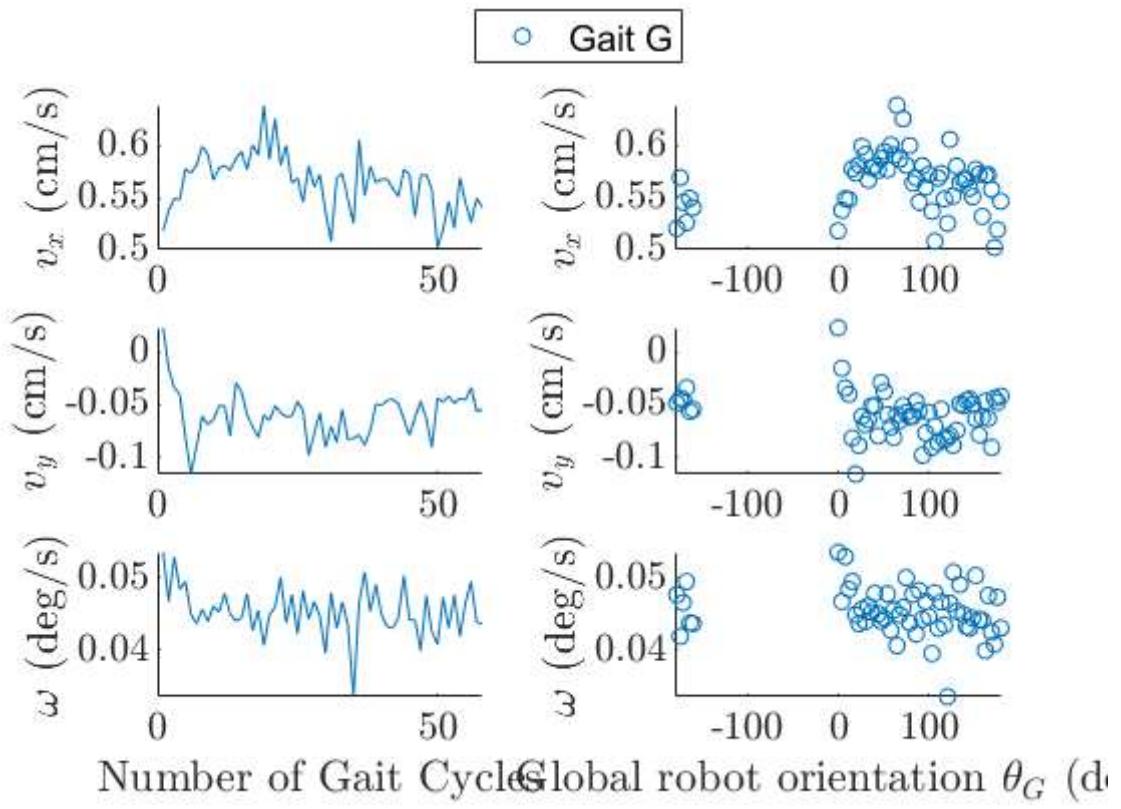


Radius of curvature

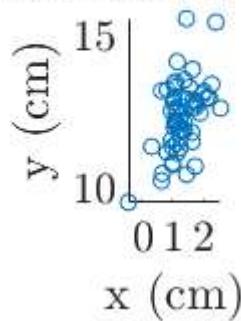


Experiment 41 : 60 cycles of Gait G with 32 AWG with slip ring tether (right , not following), t

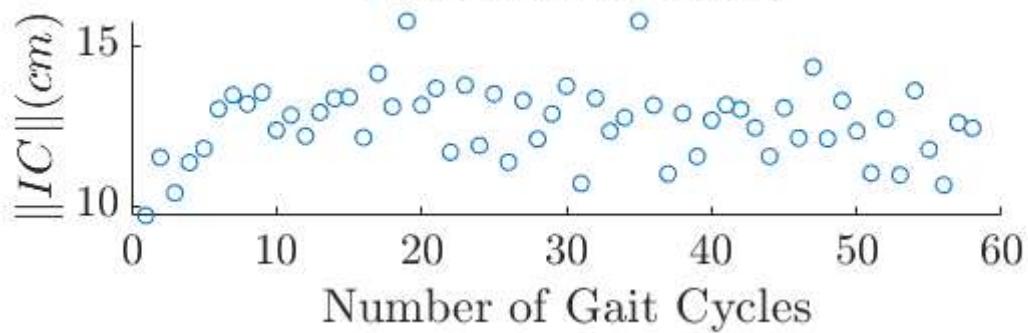




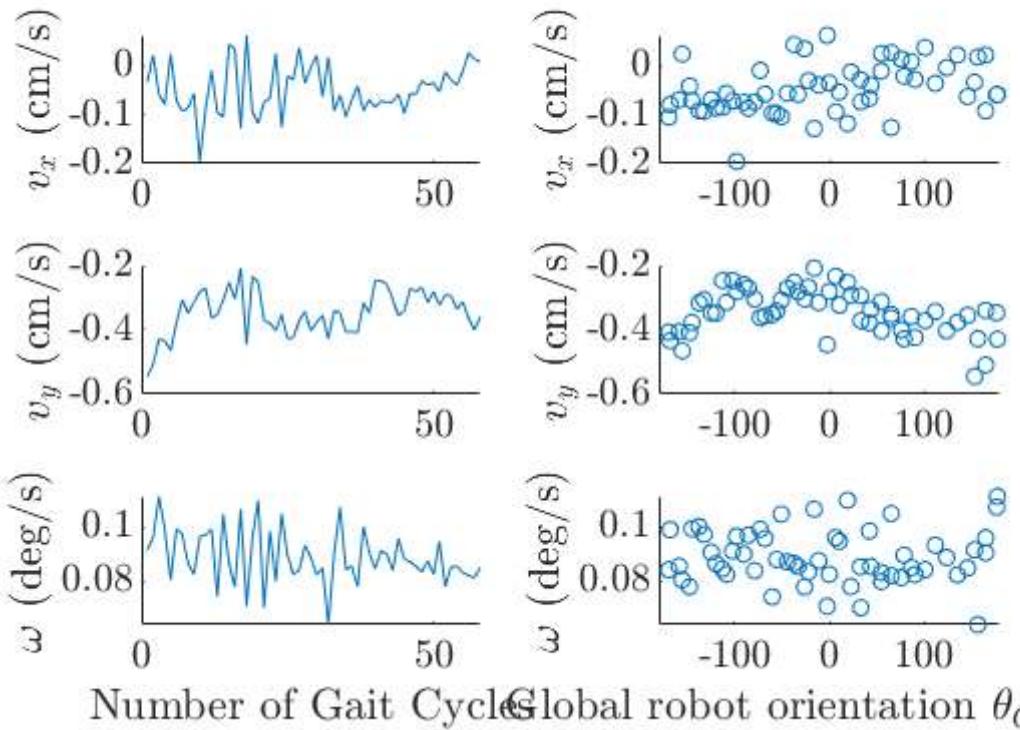
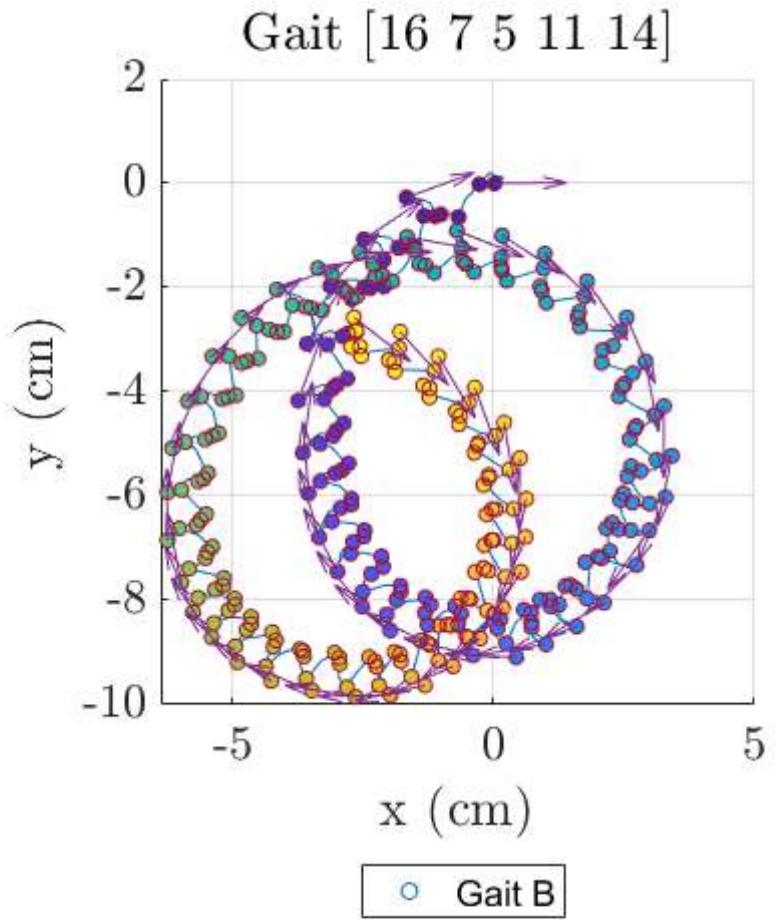
Instantaneous center of rotation IC



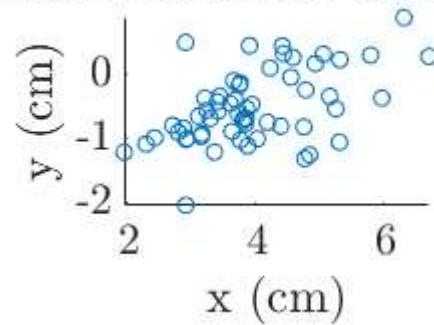
Radius of curvature



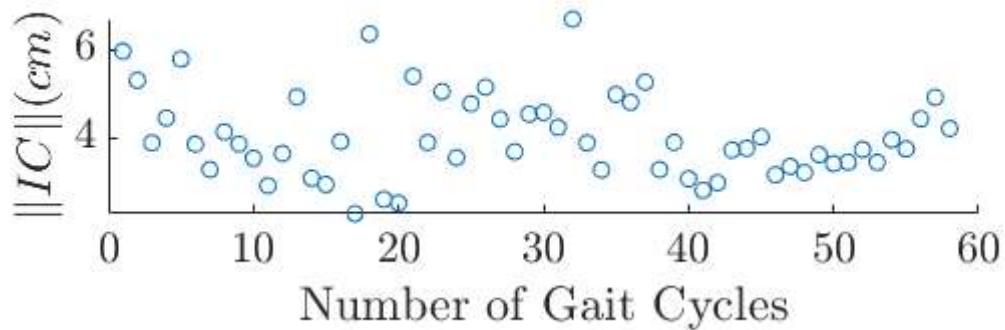
Experiment 42 : 60 cycles of Gait B with 32 AWG with slip ring tether (left , not following), tr



Instantaneous center of rotation IC

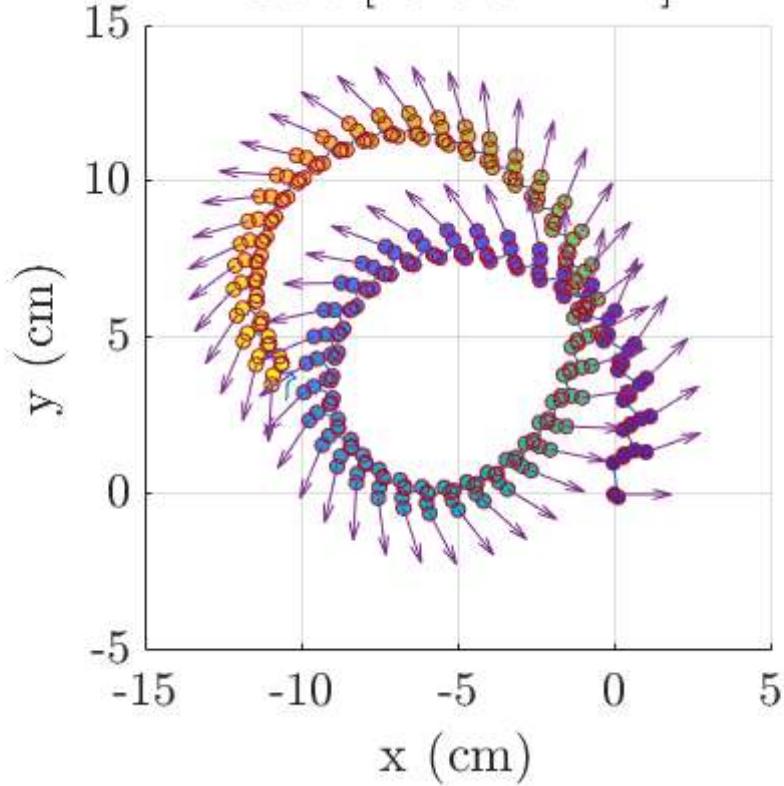


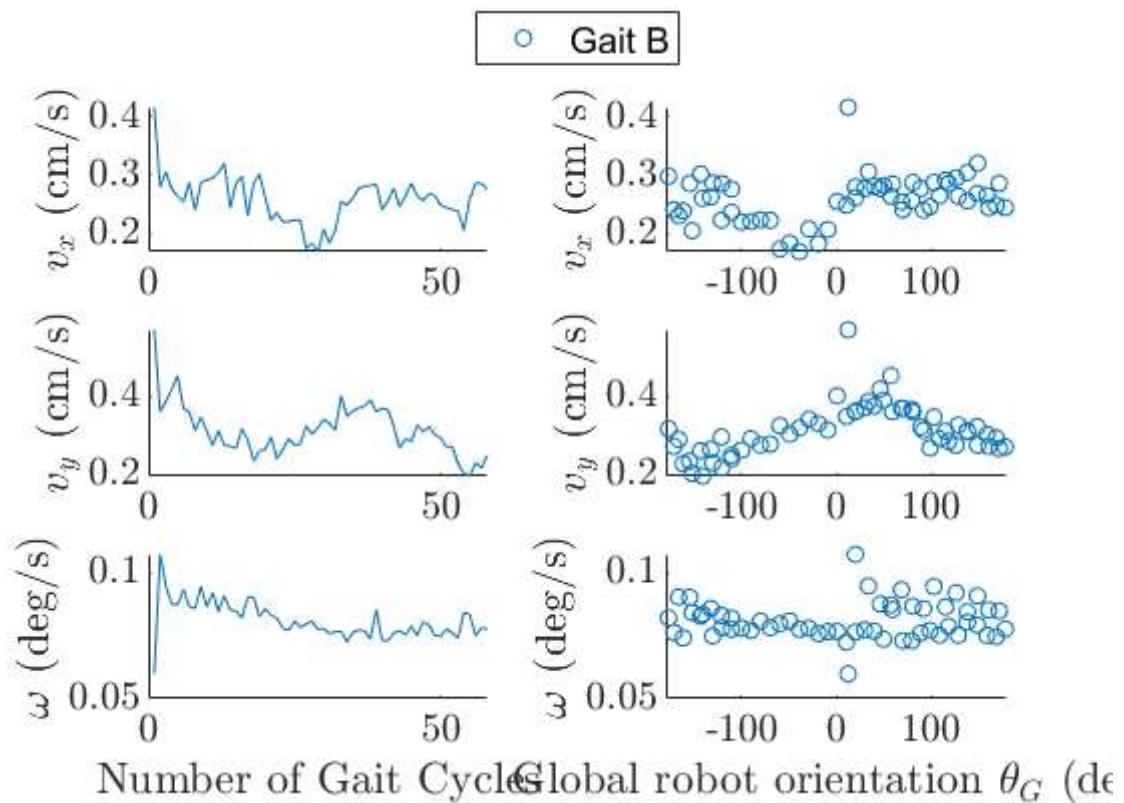
Radius of curvature



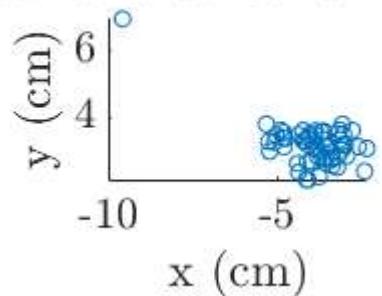
Experiment 43 : 60 cycles of Gait B with 32 AWG with slip ring tether (right , not following), t

Gait [16 7 5 11 14]

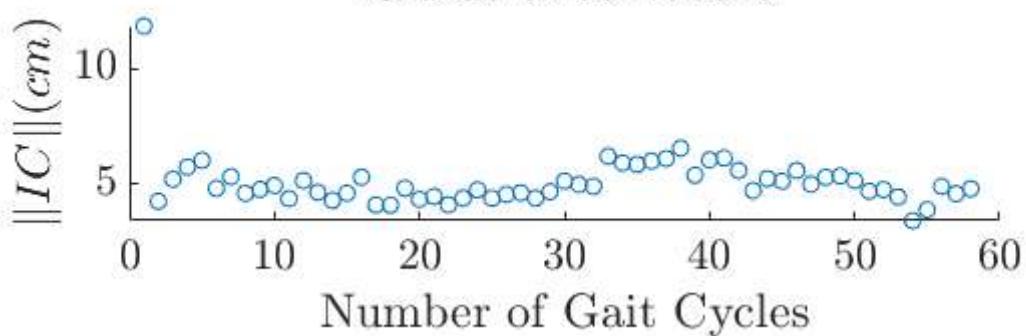




Instantaneous center of rotation IC

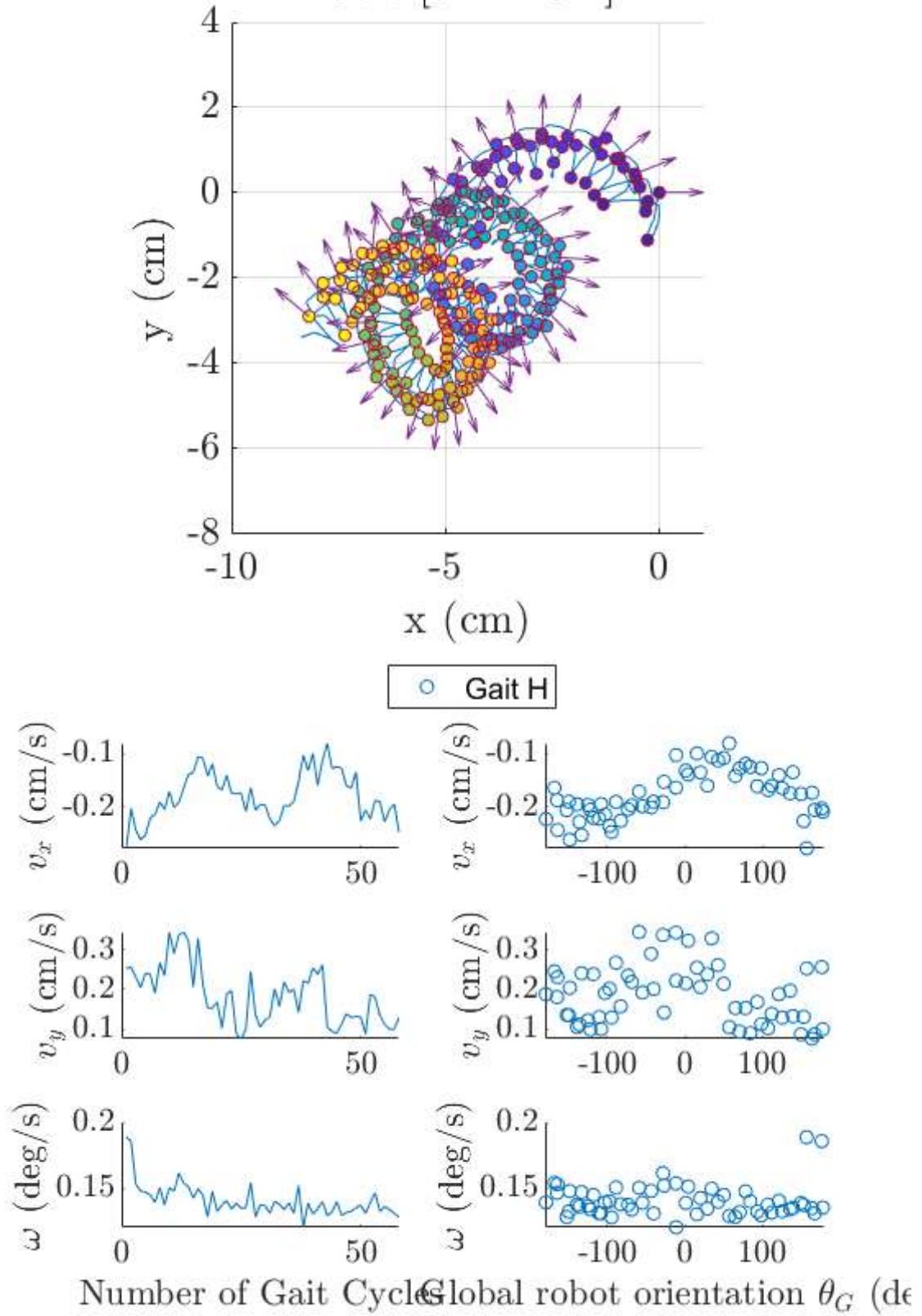


Radius of curvature

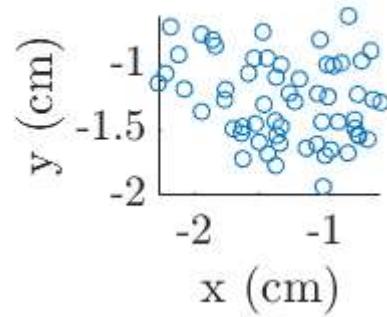


Experiment 44 : 60 cycles of Gait H with 32 AWG with slip ring tether (left , not following), tr

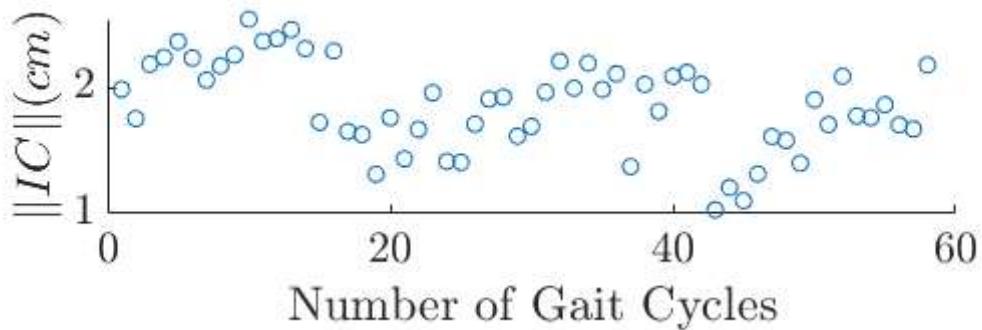
Gait [7 12 13 2]



Instantaneous center of rotation IC

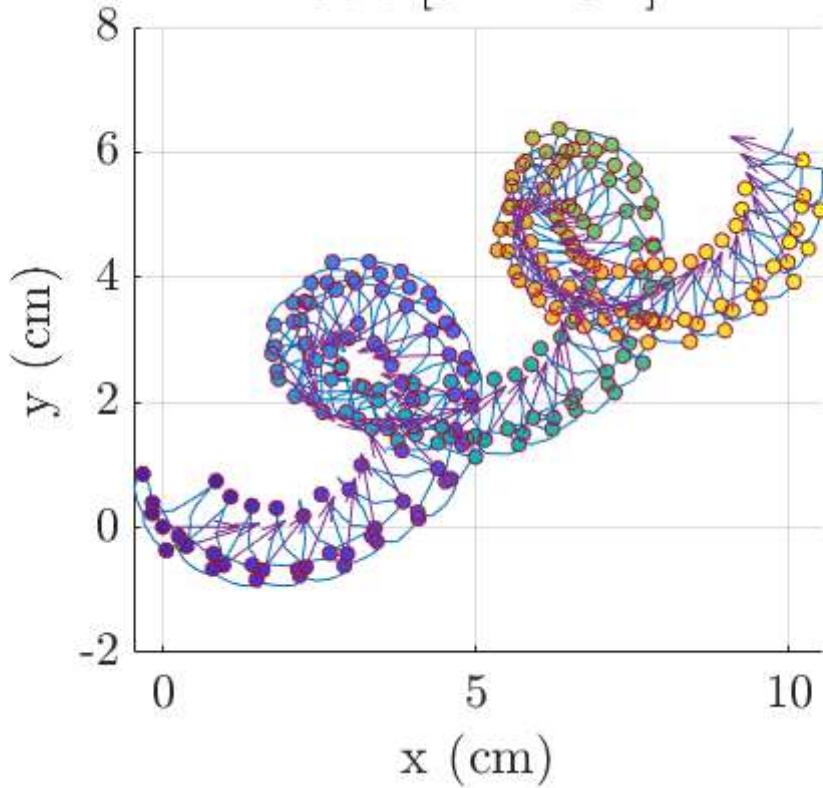


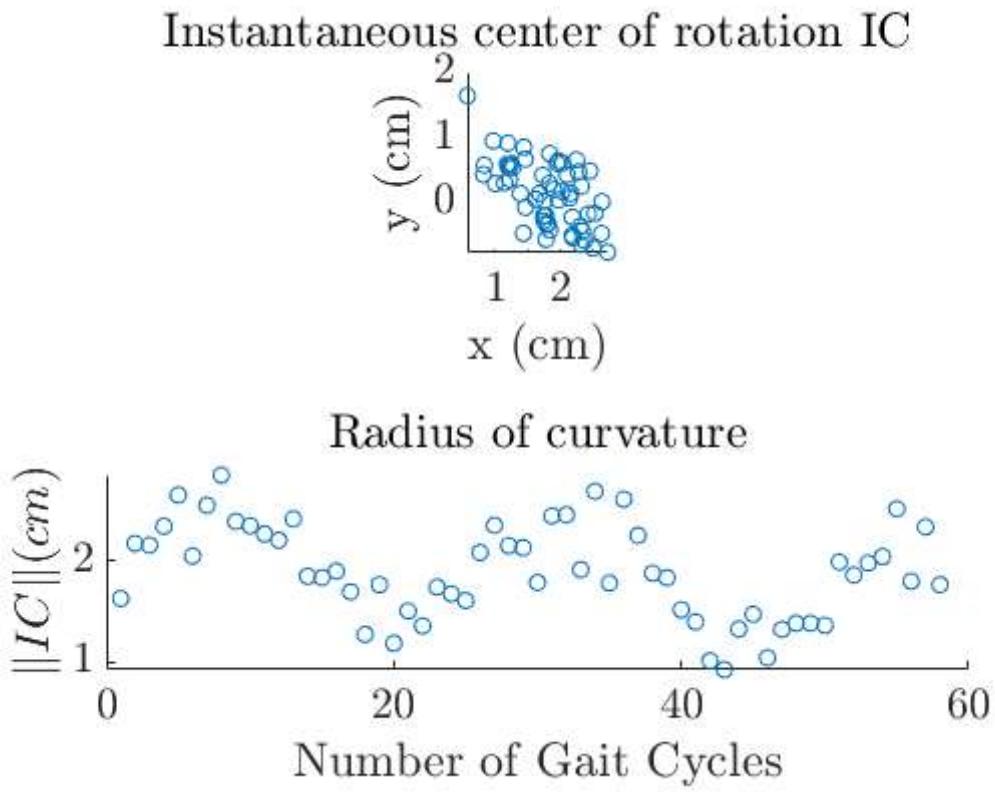
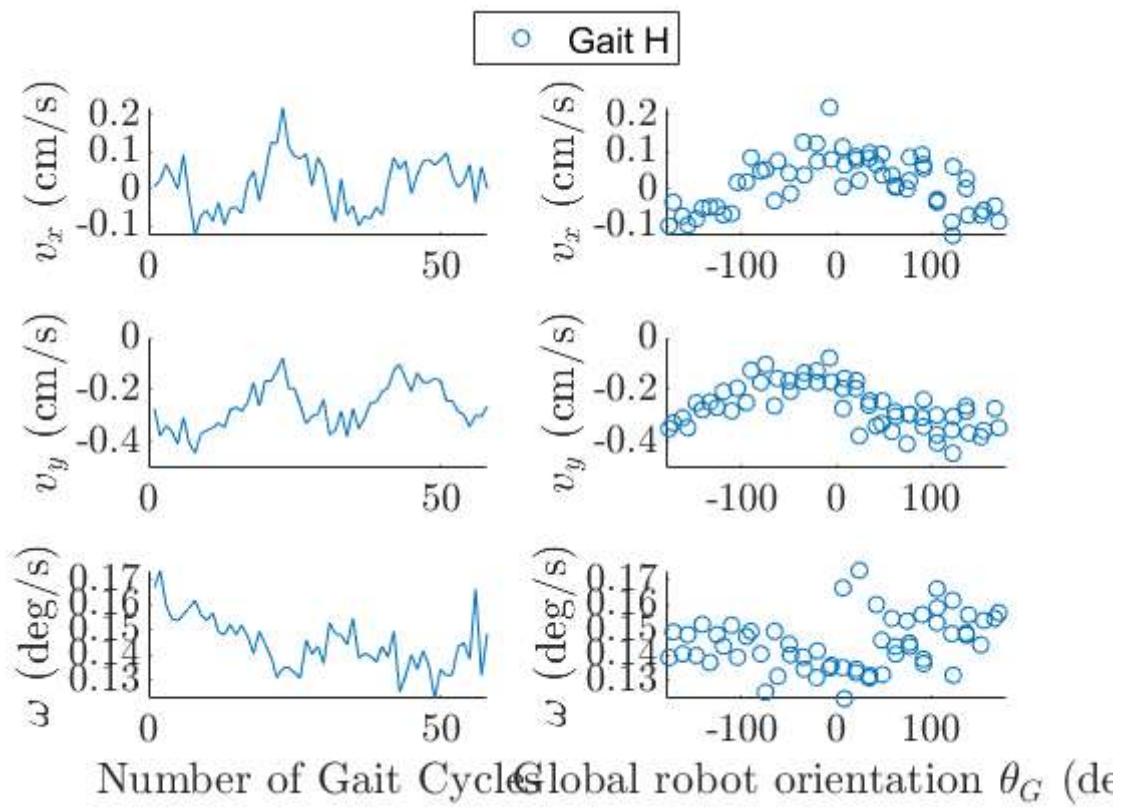
Radius of curvature



Experiment 45 : 60 cycles of Gait H with 32 AWG with slip ring tether (left , not following), tr

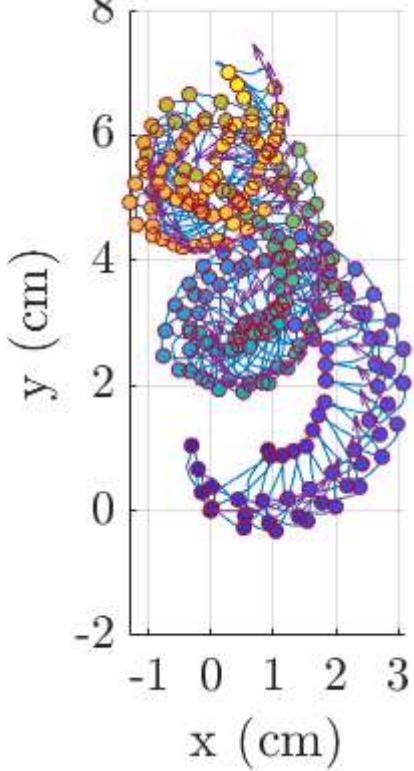
Gait [7 12 13 2]



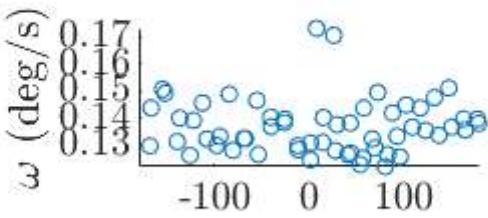
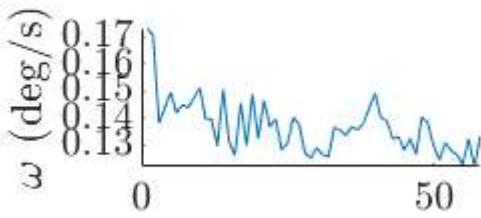
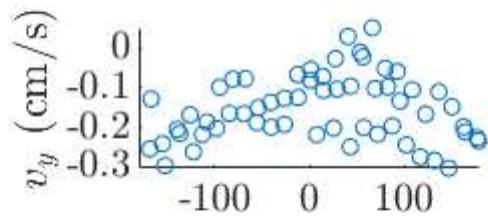
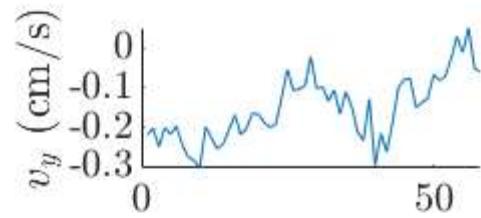
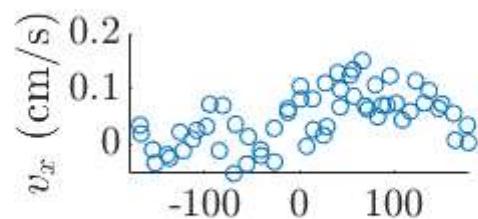
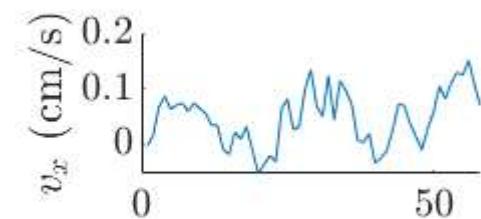


Experiment 46 : 60 cycles of Gait H with 32 AWG with slip ring tether (right , not following), t

Gait [7 12 13 2]

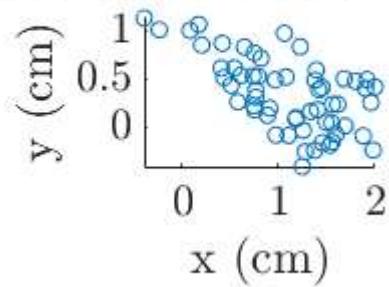


○ Gait H

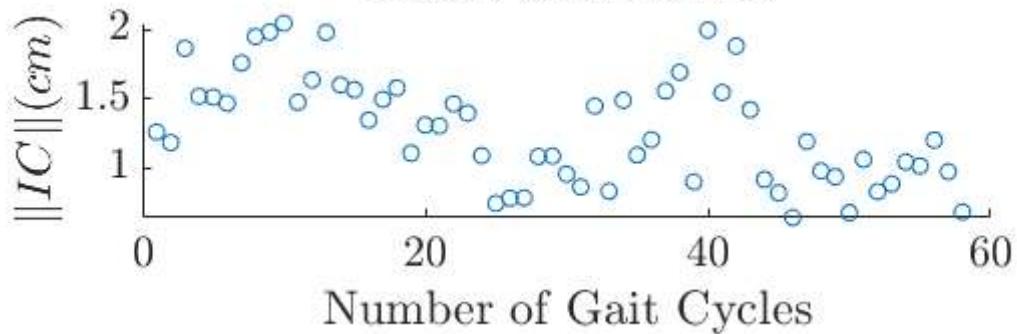


Number of Gait Cycles Global robot orientation θ_G (deg)

Instantaneous center of rotation IC

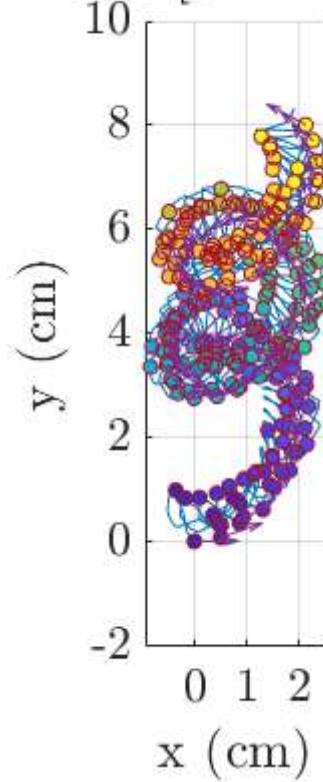


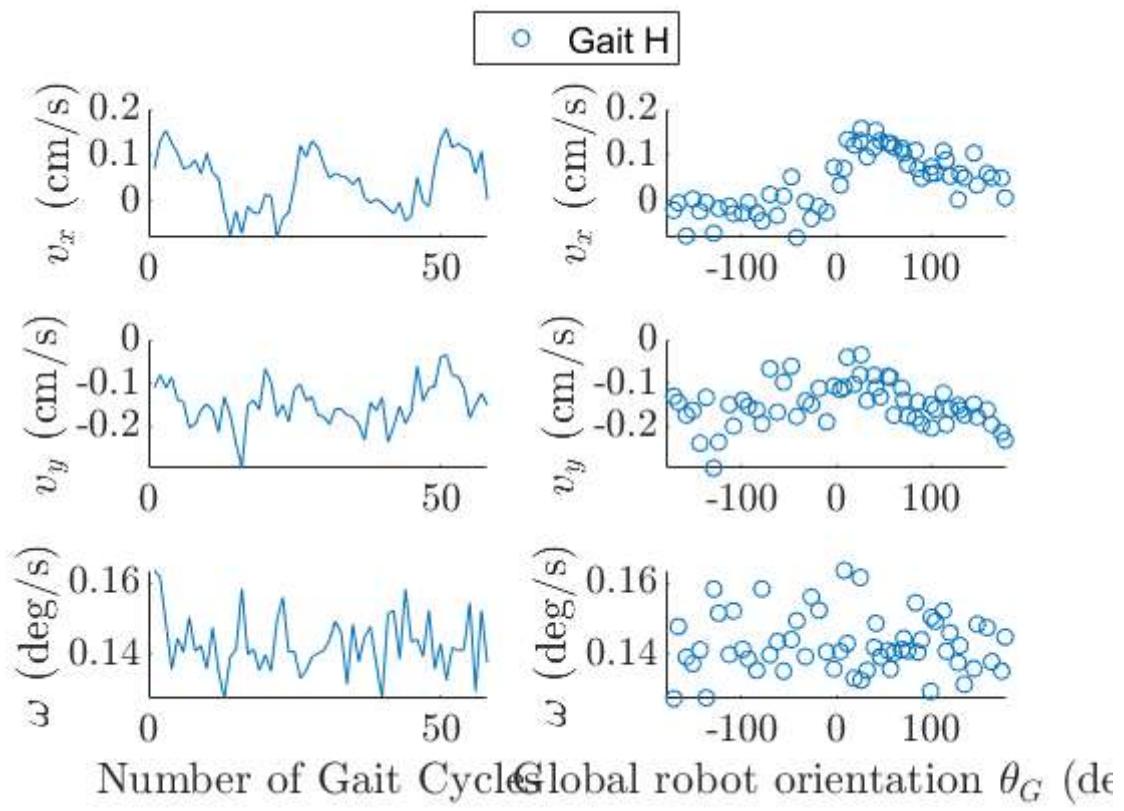
Radius of curvature



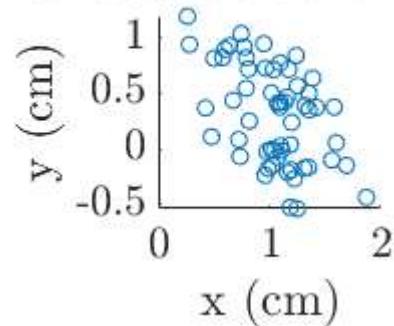
Experiment 47 : 60 cycles of Gait H with 32 AWG with slip ring tether (right , not following), t

Gait [7 12 13 2]

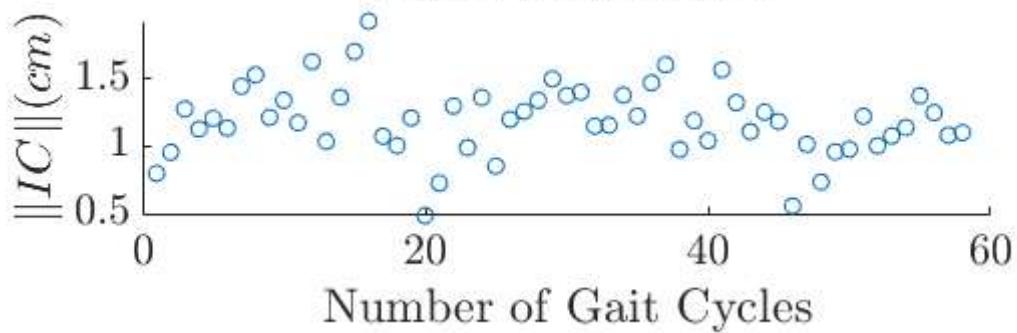




Instantaneous center of rotation IC

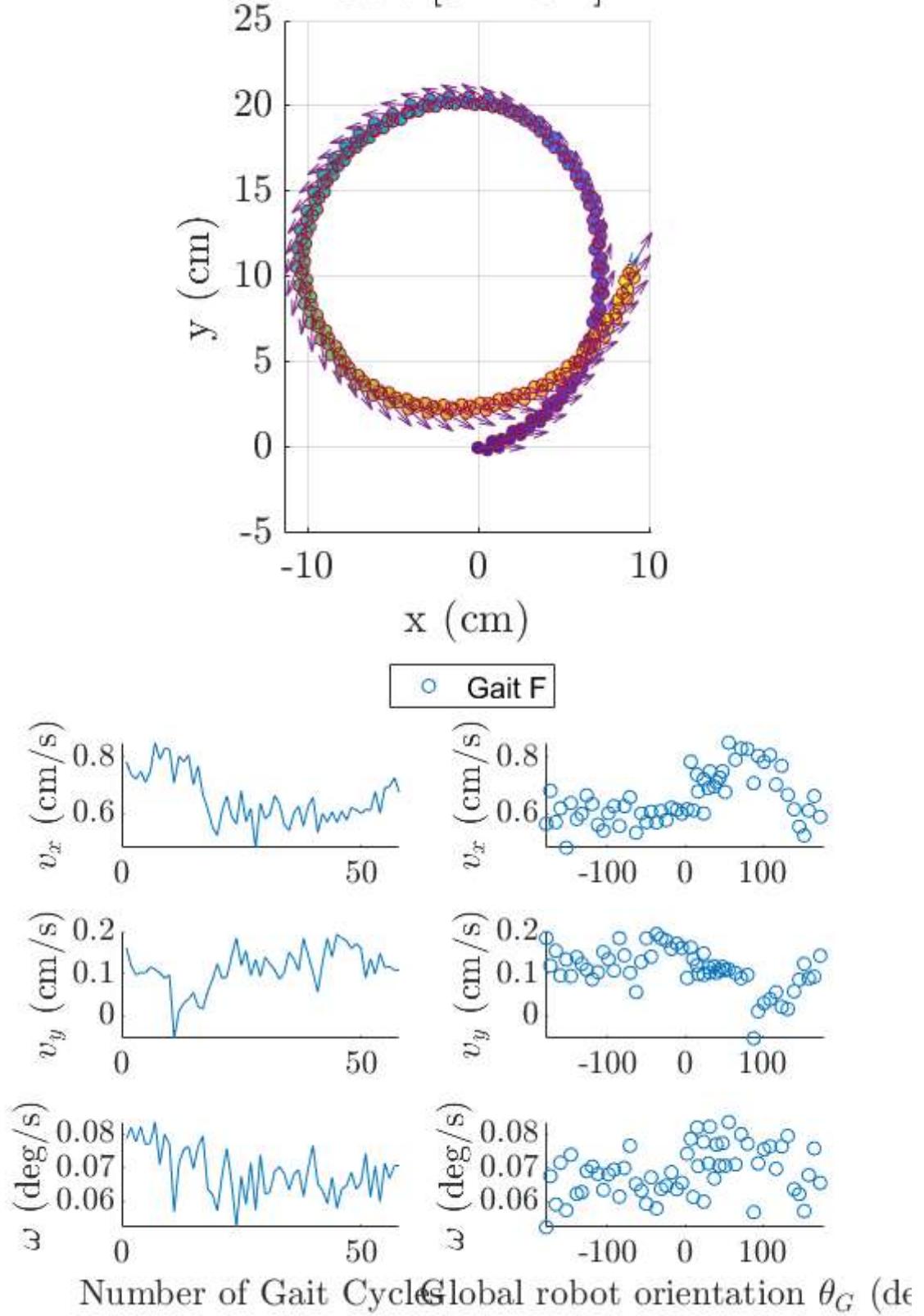


Radius of curvature

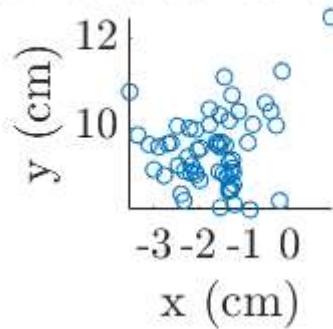


Experiment 48 : 60 cycles of Gait F with 32 AWG with slip ring tether (right , not following), t

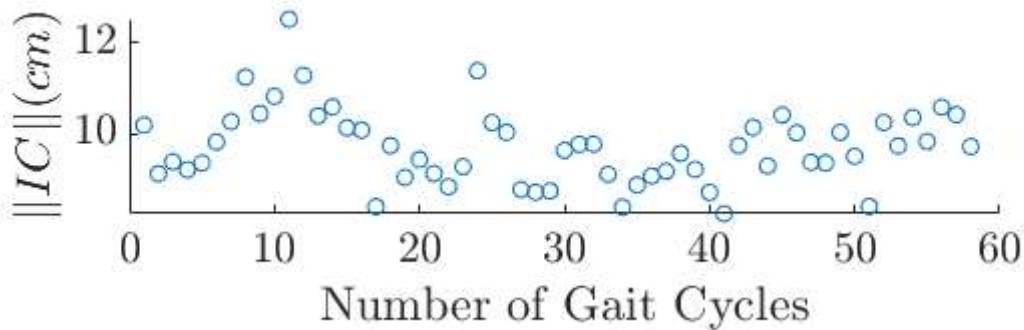
Gait [9 14 8 1]



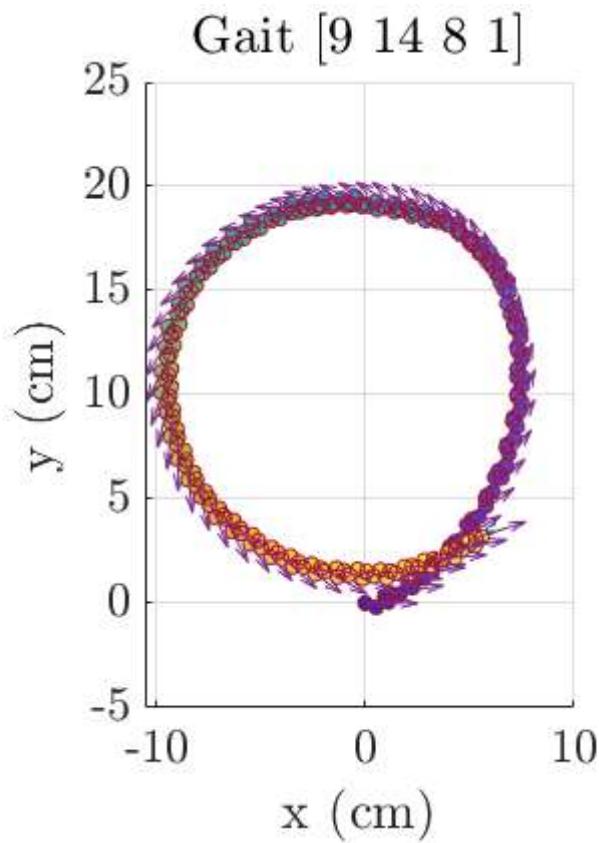
Instantaneous center of rotation IC

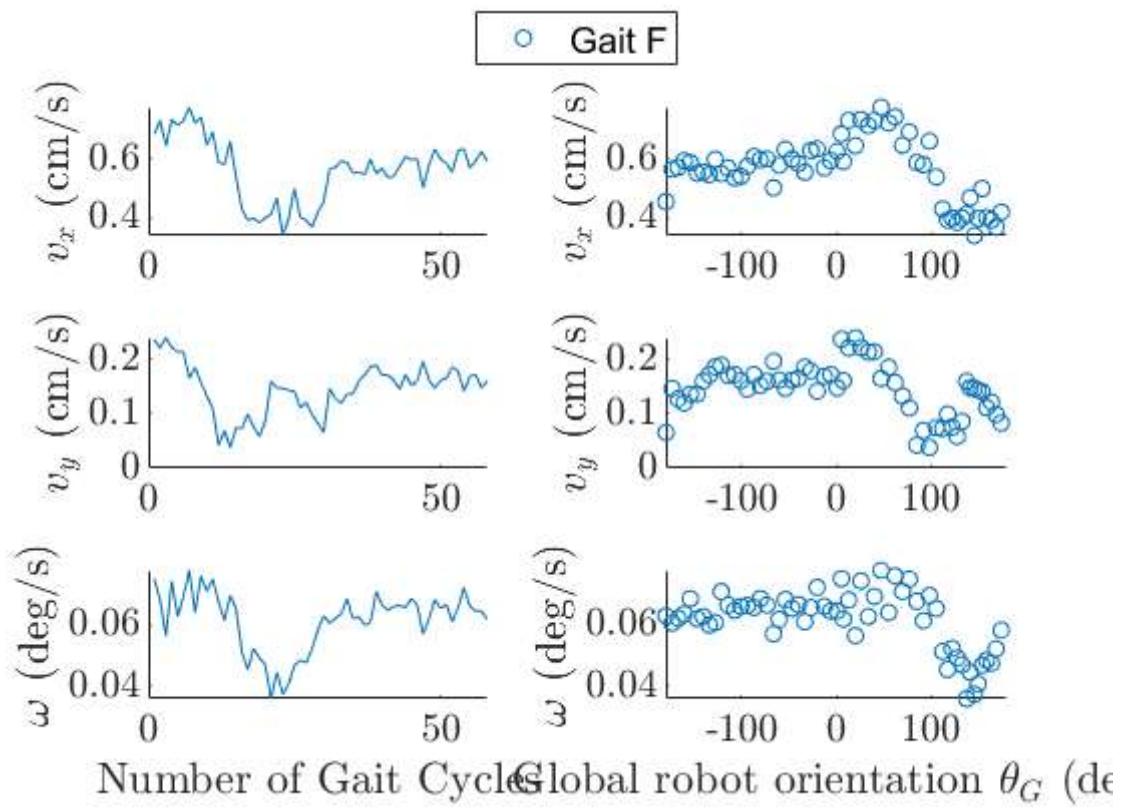


Radius of curvature

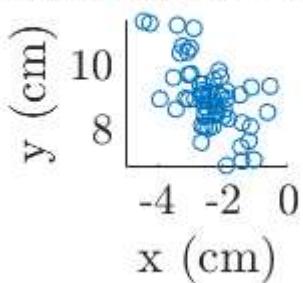


Experiment 49 : 60 cycles of Gait F with 32 AWG with slip ring tether (right , not following), t





Instantaneous center of rotation IC



Radius of curvature

