

APPENDIX : ALL OPTIMIZATION



Author:
Jonathan GRIZOU

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Abstract

This document has been generated automatically, it may contain strange formatting. The document contain the results of all the different optimization performed on the final Webots setup.

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1 Opti_9seg_notail_w62_Full_1Hz_1

1.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_1/Opti_9seg_notail_w62_Full_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	141.683	124.081	91.776	63.493	39.526	11.869	13.486	82.165
Lopt (m)	0.070	0.070	0.071	0.071	0.081	0.080	0.101	0.118
r (m)	0.136	0.138	0.137	0.131	0.086	0.131	0.137	0.140
TimeLag (s)	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686
error	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264
Fitness	3.791	3.791	3.791	3.791	3.791	3.791	3.791	3.791

Table 1.1: Optimised Parameters

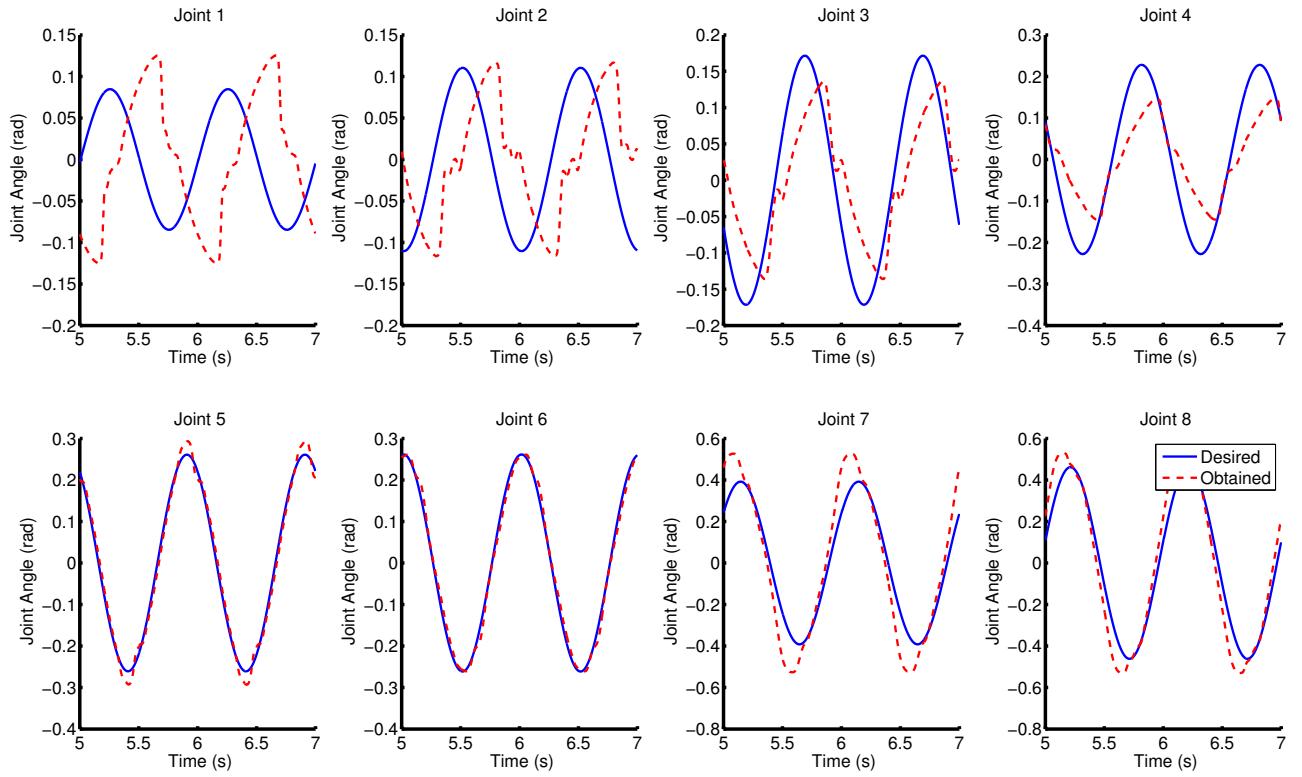


Figure 1.1: AngleDiff_Opti_9seg_notail_w62_Full_1Hz_1

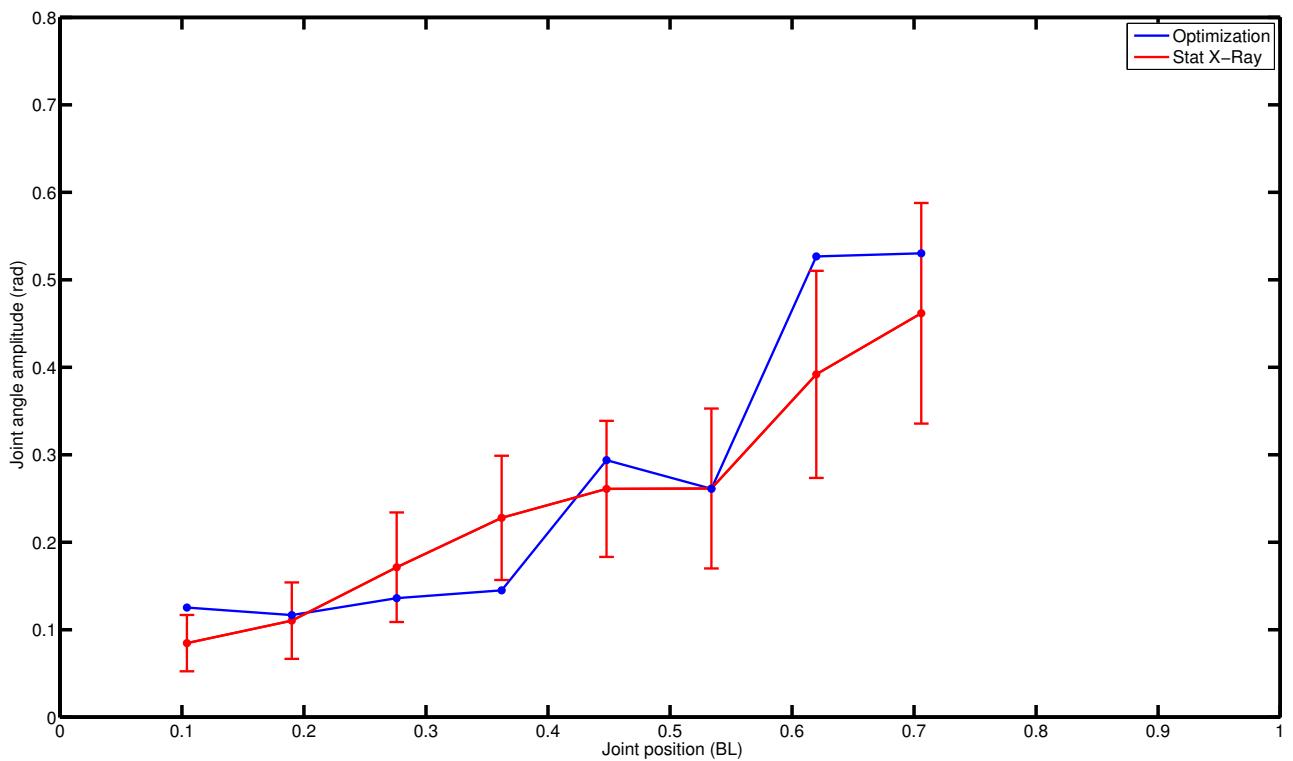


Figure 1.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_1Hz_1

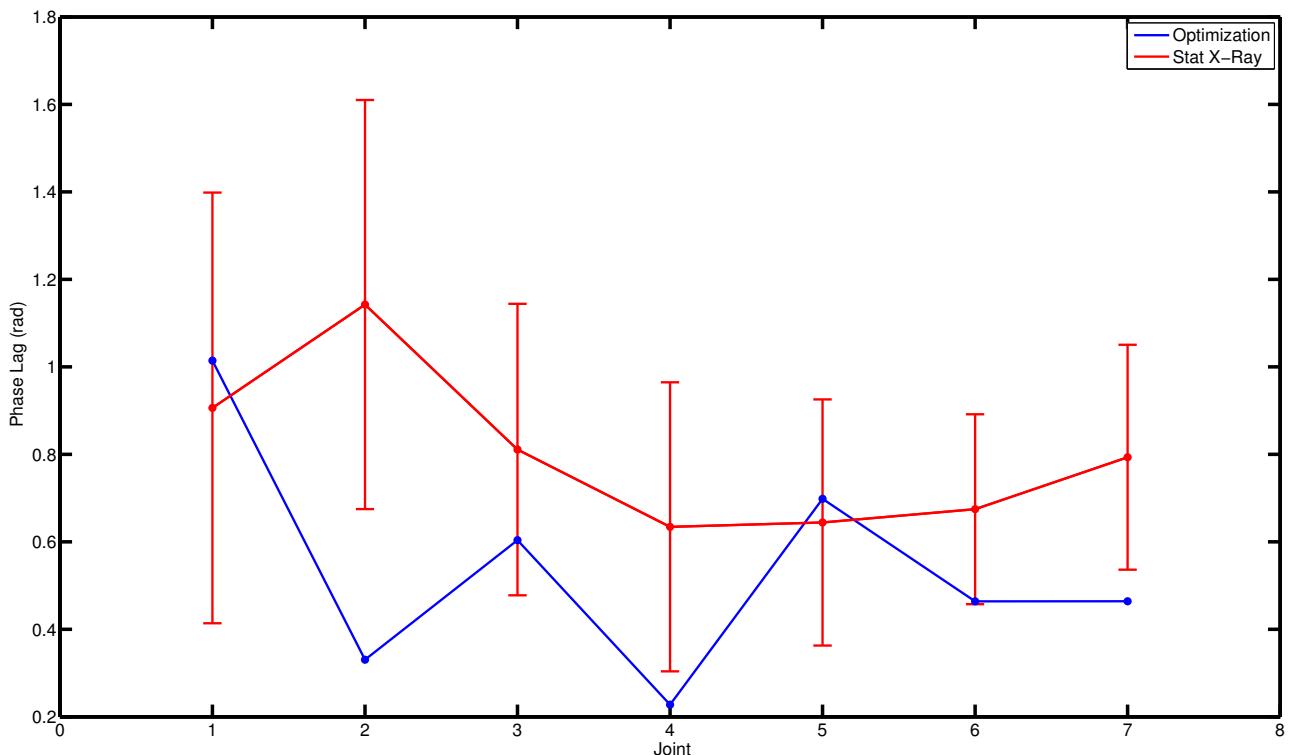


Figure 1.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_1Hz_1

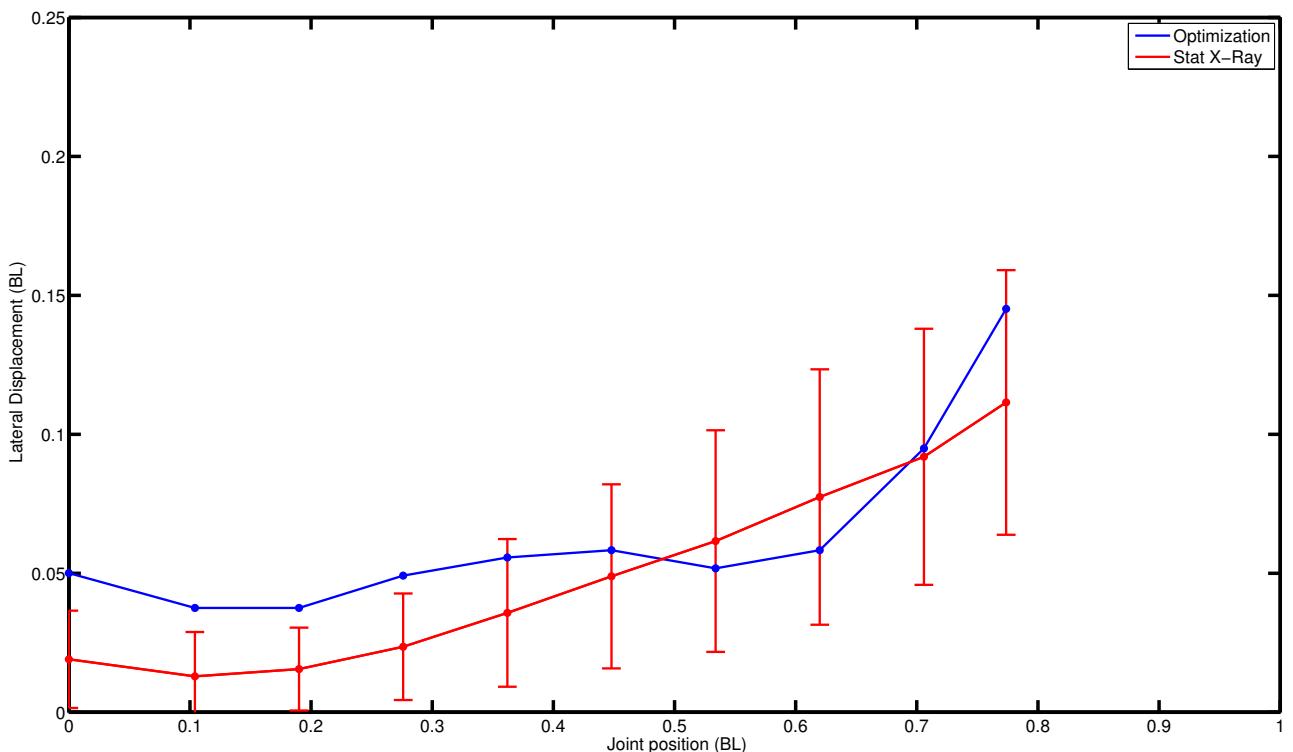


Figure 1.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.050	NaN	NaN
Joint 1	0.038	0.125	NaN
Joint 2	0.038	0.117	1.014
Joint 3	0.049	0.136	0.330
Joint 4	0.056	0.145	0.604
Joint 5	0.058	0.294	0.228
Joint 6	0.052	0.261	0.698
Joint 7	0.058	0.527	0.464
Joint 8	0.095	0.530	0.464
Joint 9	0.145	NaN	NaN

Table 1.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.262	1.010	3.854

Table 1.3: Speed data

1.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_1.mp4

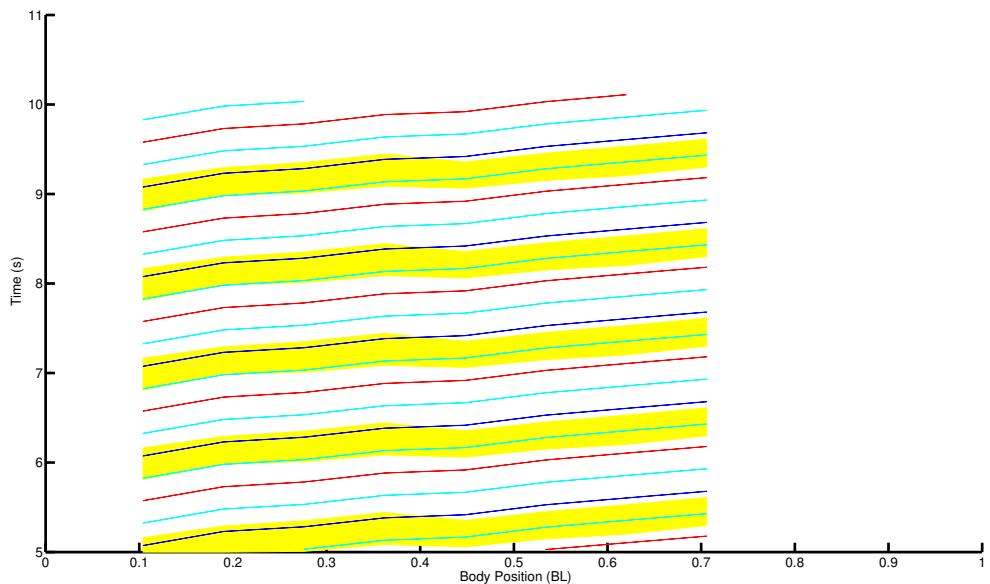


Figure 1.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_1

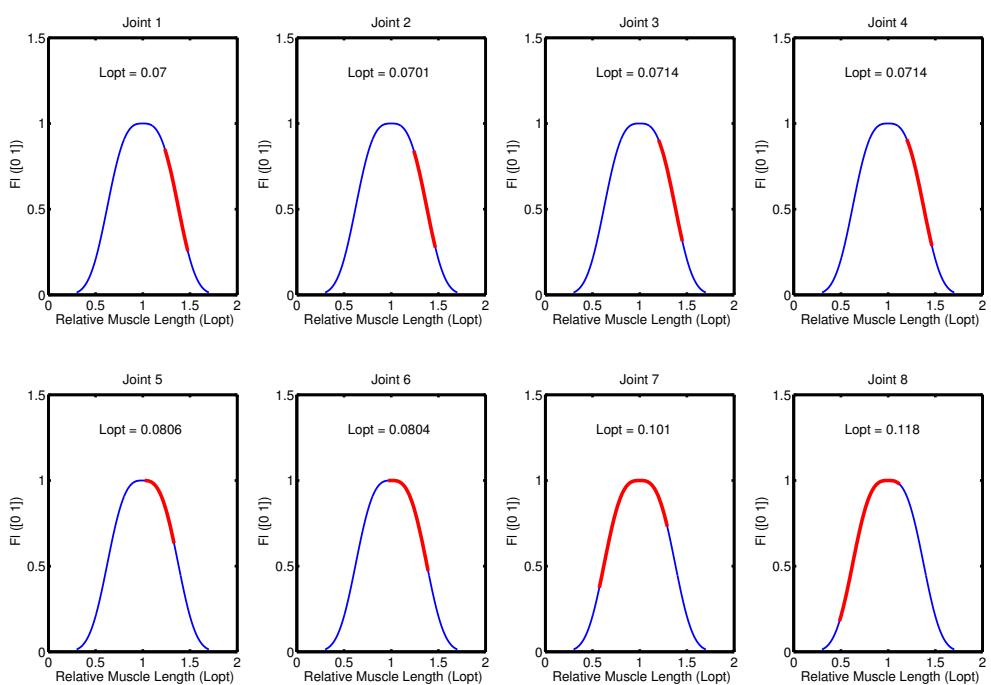


Figure 1.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_1Hz_1

1.3 Energy

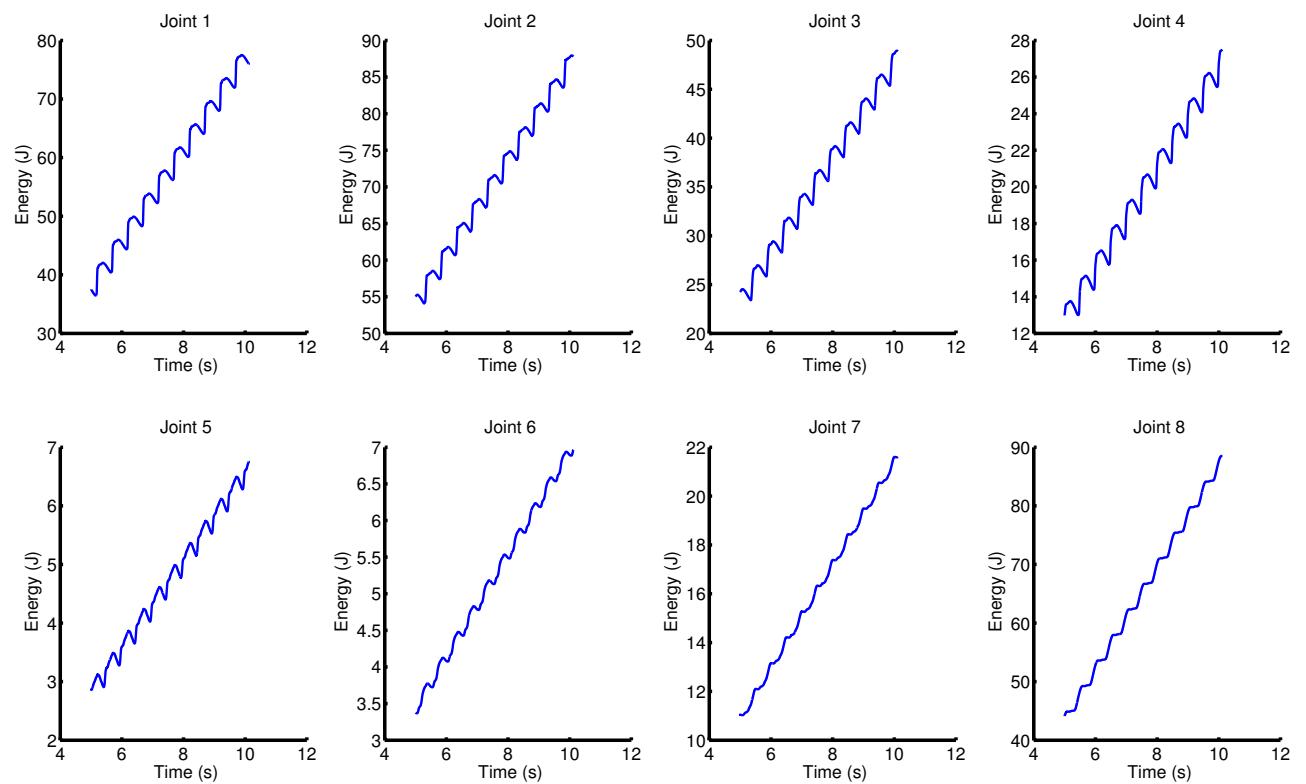


Figure 1.7: Energy_Opti_9seg_notaill_w62_Full_1Hz_1

2 Opti_9seg_notail_w62_Full_1Hz_3

2.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_3/Opti_9seg_notail_w62_Full_1Hz_3.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	146.793	2.216	22.081	46.488	31.961	36.553	28.343	98.835
Lopt (m)	0.070	0.075	0.142	0.073	0.096	0.085	0.104	0.121
r (m)	0.115	0.115	0.030	0.106	0.101	0.091	0.138	0.140
TimeLag (s)	0.708	0.708	0.708	0.708	0.708	0.708	0.708	0.708
error	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342
Fitness	2.928	2.928	2.928	2.928	2.928	2.928	2.928	2.928

Table 2.1: Optimised Parameters

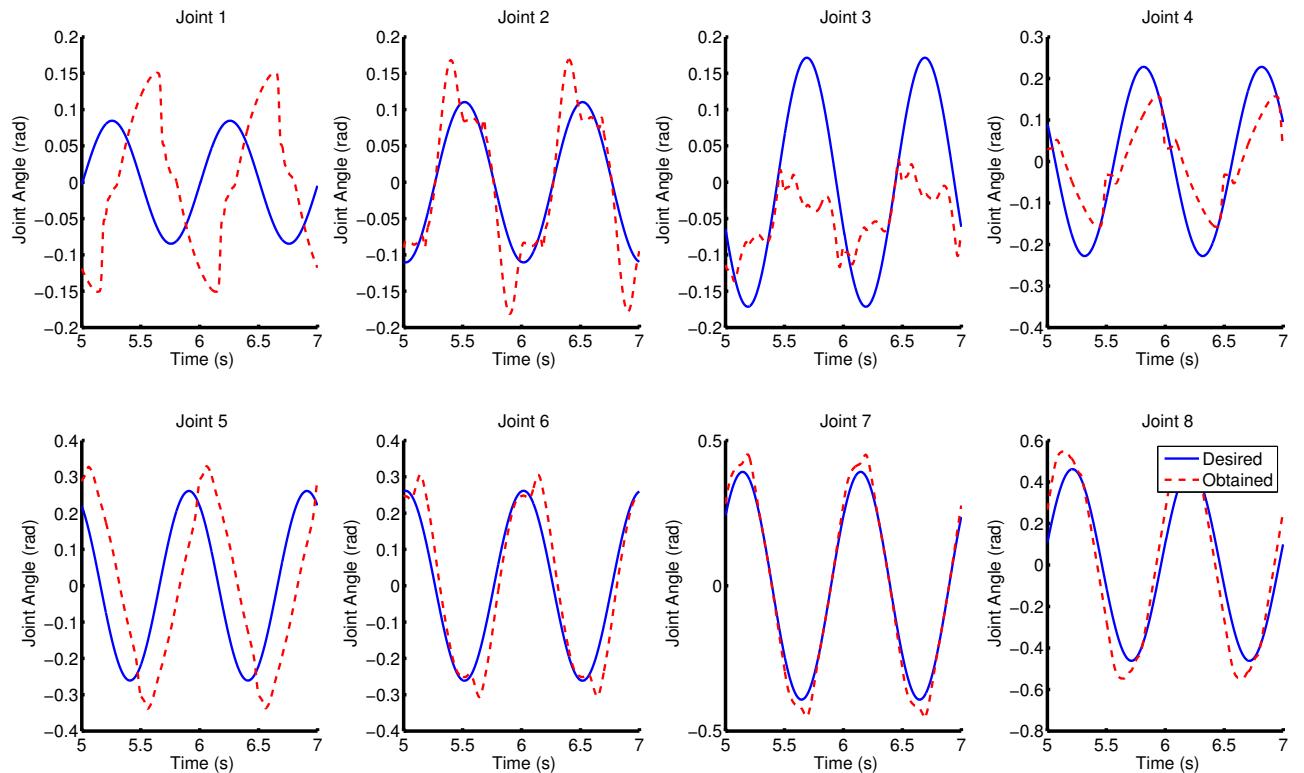


Figure 2.1: AngleDiff_Opti_9seg_notail_w62_Full_1Hz_3

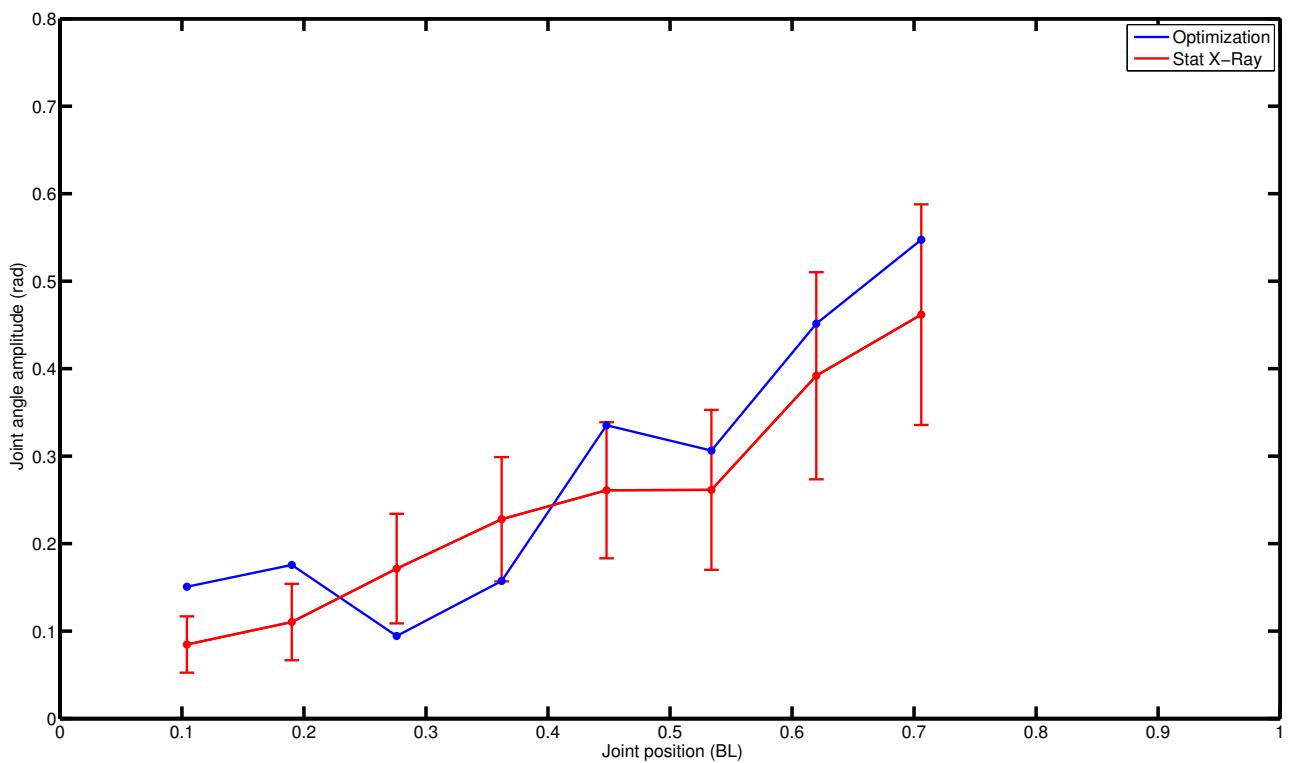


Figure 2.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_1Hz_3

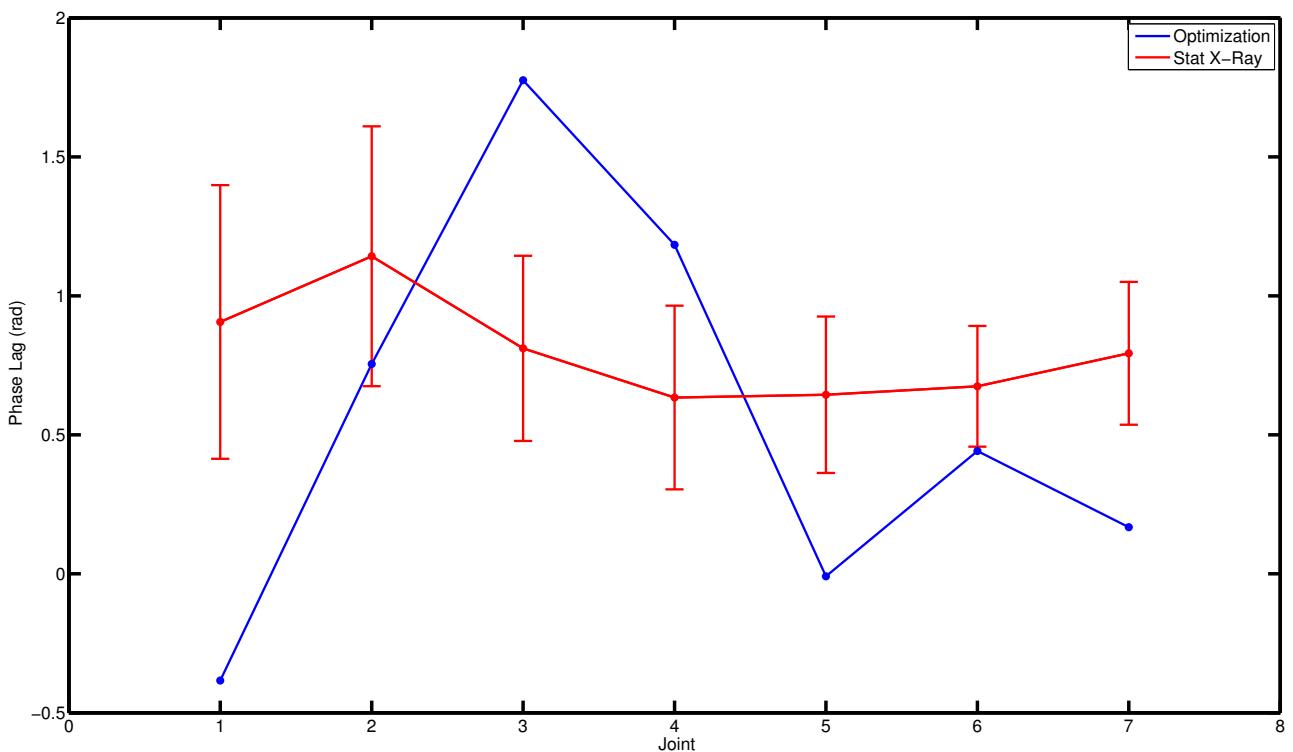


Figure 2.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_1Hz_3

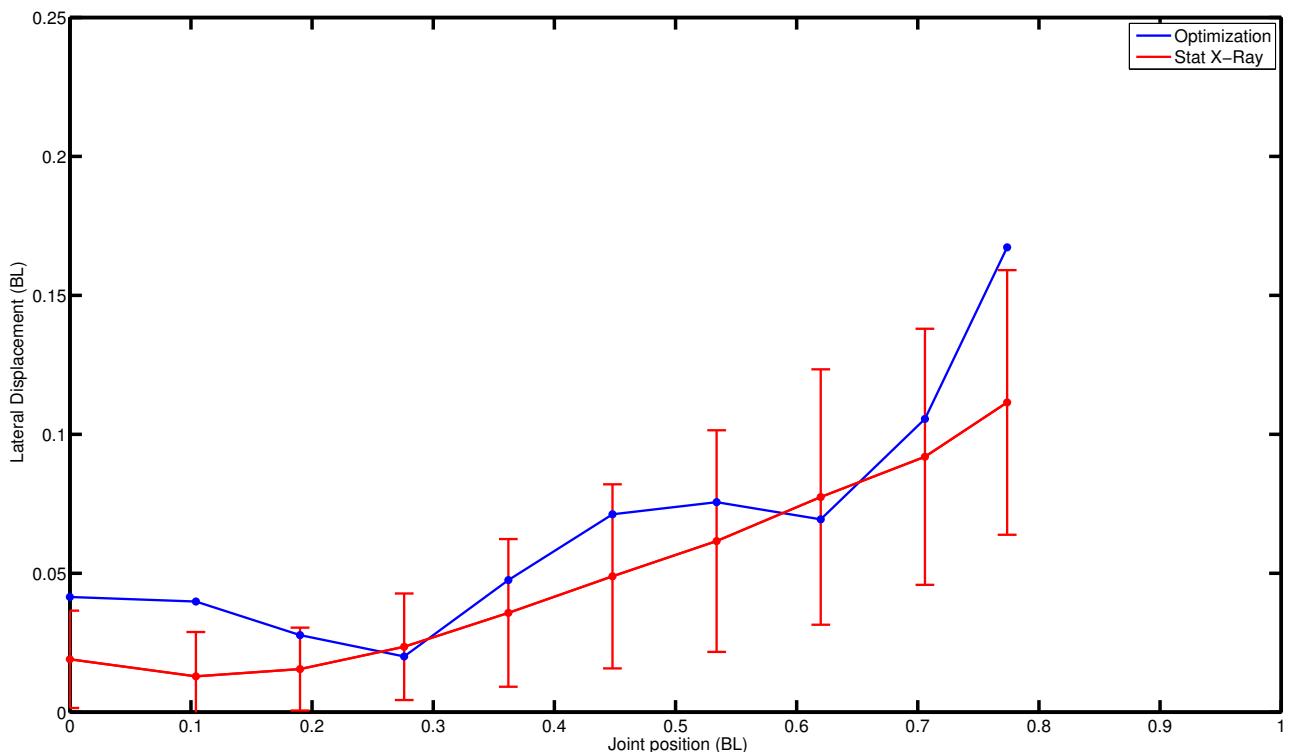


Figure 2.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_1Hz_3

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.041	NaN	NaN
Joint 1	0.040	0.151	NaN
Joint 2	0.028	0.176	-0.384
Joint 3	0.020	0.094	0.755
Joint 4	0.048	0.157	1.776
Joint 5	0.071	0.335	1.184
Joint 6	0.076	0.306	-0.009
Joint 7	0.069	0.451	0.442
Joint 8	0.106	0.547	0.168
Joint 9	0.167	NaN	NaN

Table 2.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.198	0.039	0.199

Table 2.3: Speed data

2.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_3/BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_3.mp4

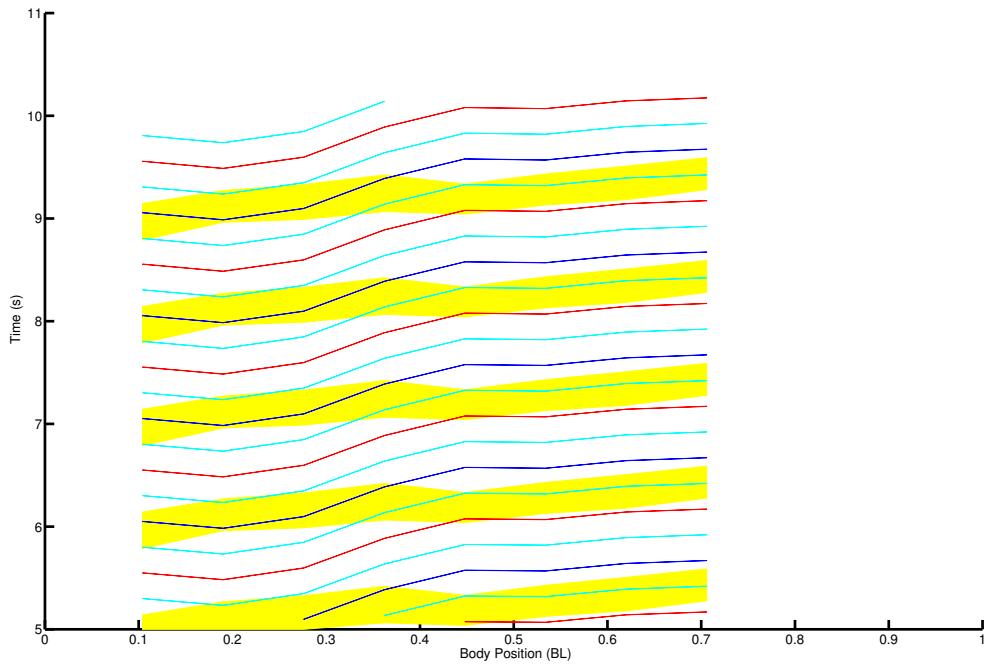


Figure 2.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_3

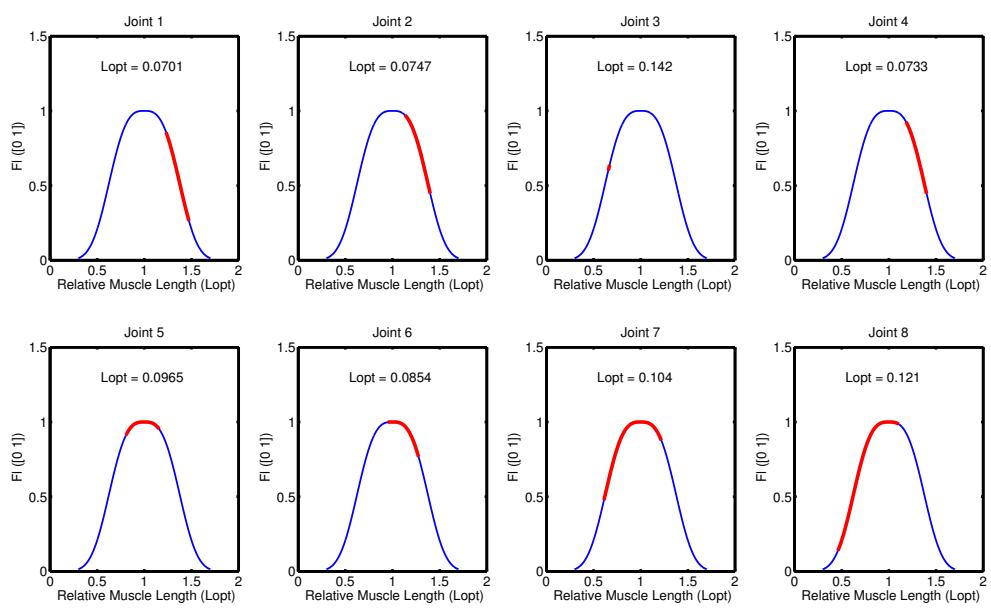


Figure 2.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_1Hz_3

2.3 Energy

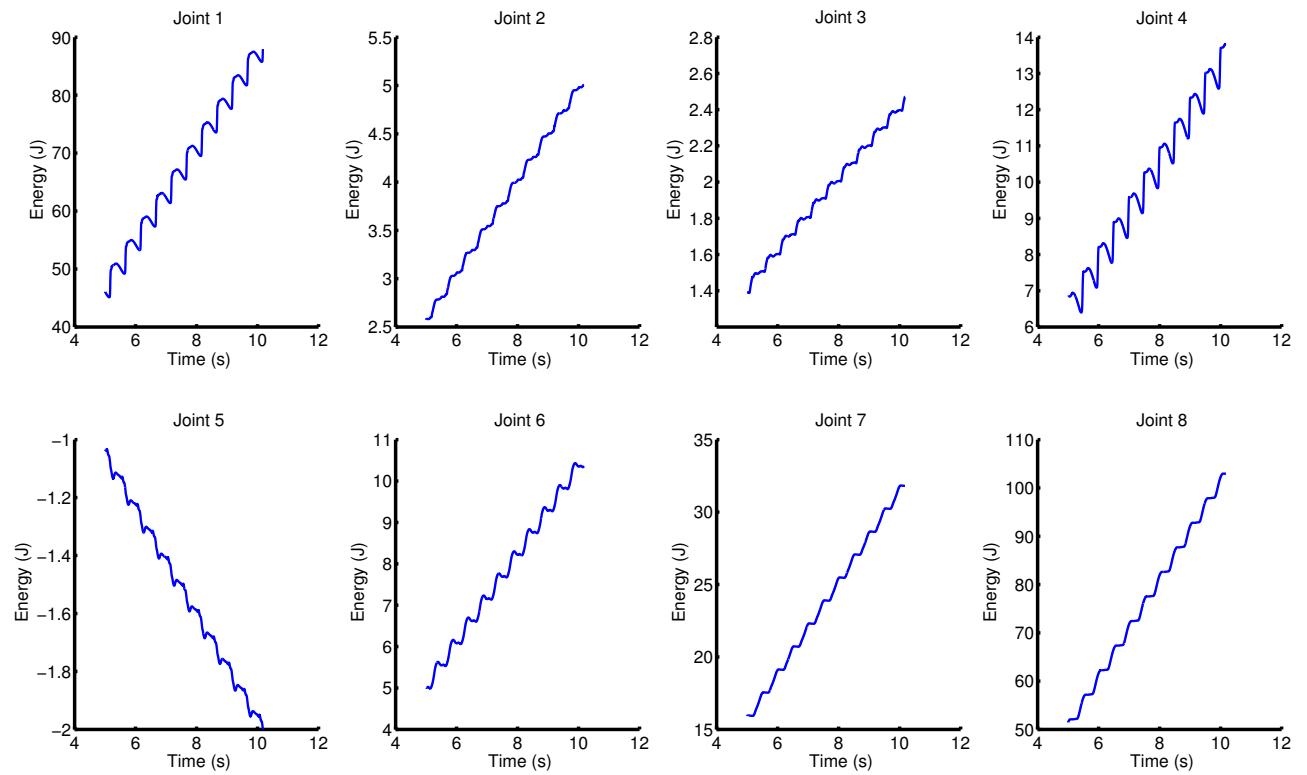


Figure 2.7: Energy_Opti_9seg_nottail_w62_Full_1Hz_3

3 Opti_9seg_notail_w62_Full_1Hz_4

3.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_4/Opti_9seg_notail_w62_Full_1Hz_4.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	1.177	109.357	110.778	143.568	70.498	37.455	85.023	160.967
Lopt (m)	0.084	0.070	0.070	0.072	0.076	0.090	0.108	0.111
r (m)	0.118	0.133	0.124	0.118	0.071	0.135	0.140	0.139
TimeLag (s)	0.646	0.646	0.646	0.646	0.646	0.646	0.646	0.646
error	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229
Fitness	4.362	4.362	4.362	4.362	4.362	4.362	4.362	4.362

Table 3.1: Optimised Parameters

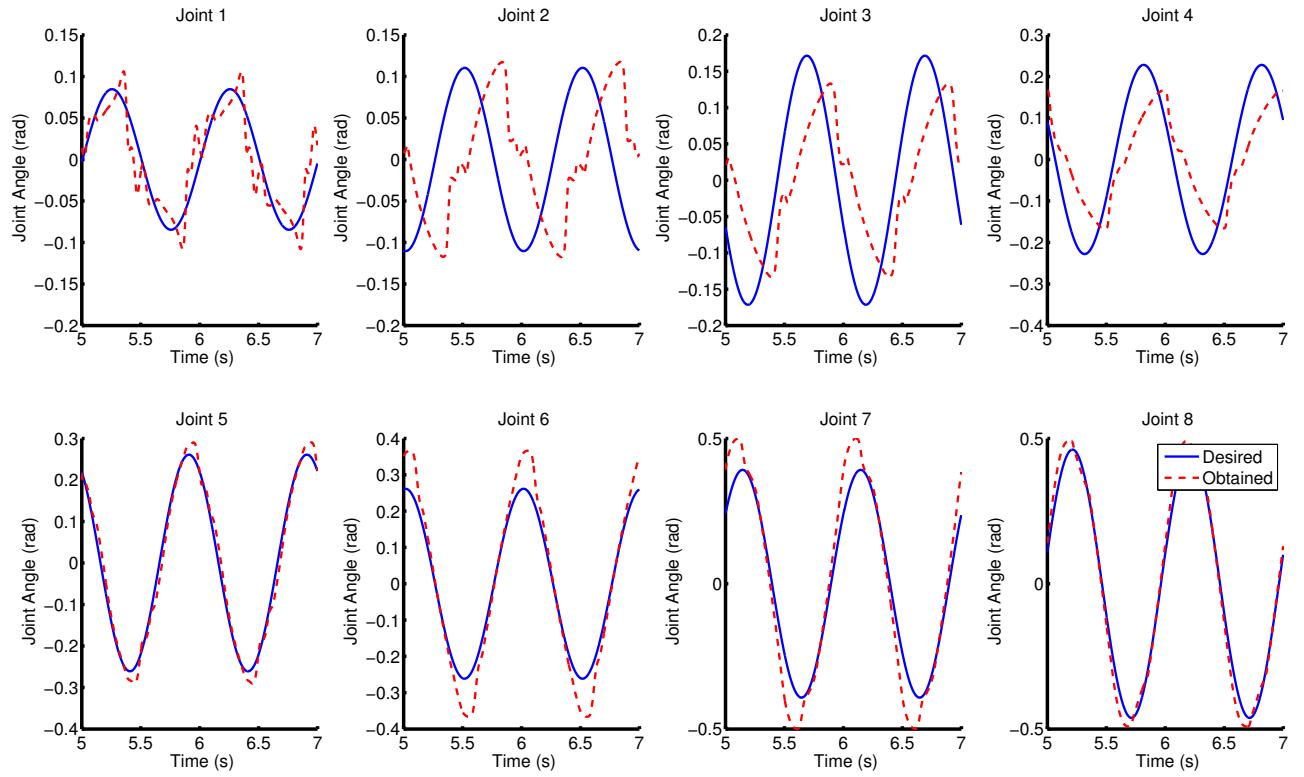


Figure 3.1: AngleDiff_Opti_9seg_notail_w62_Full_1Hz_4

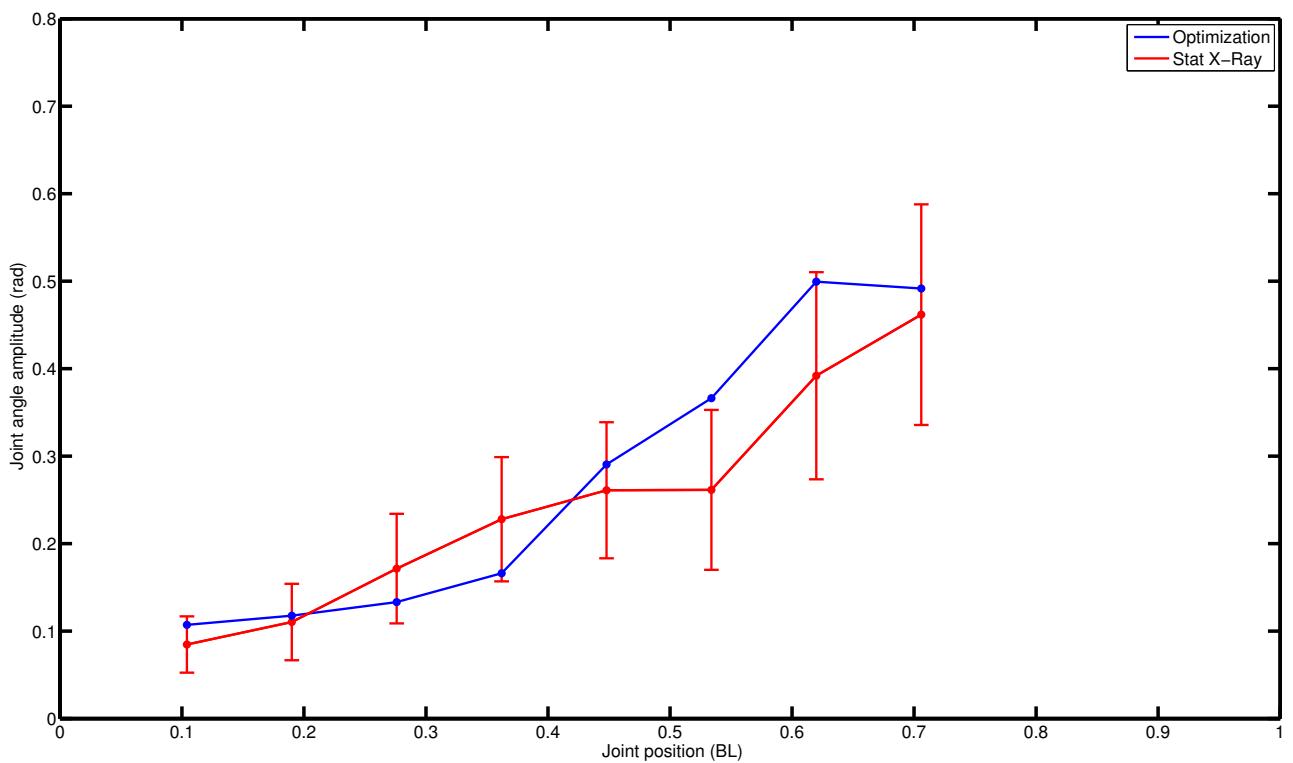


Figure 3.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_1Hz_4

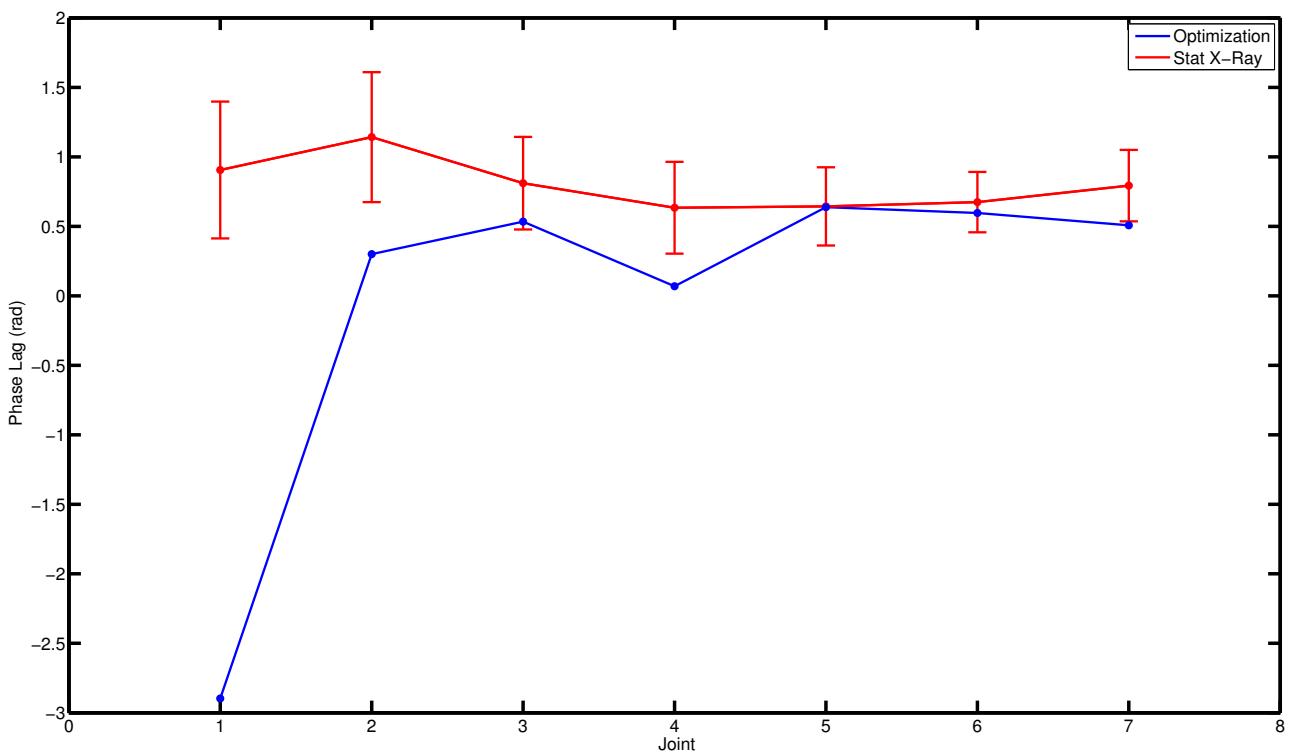


Figure 3.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_1Hz_4

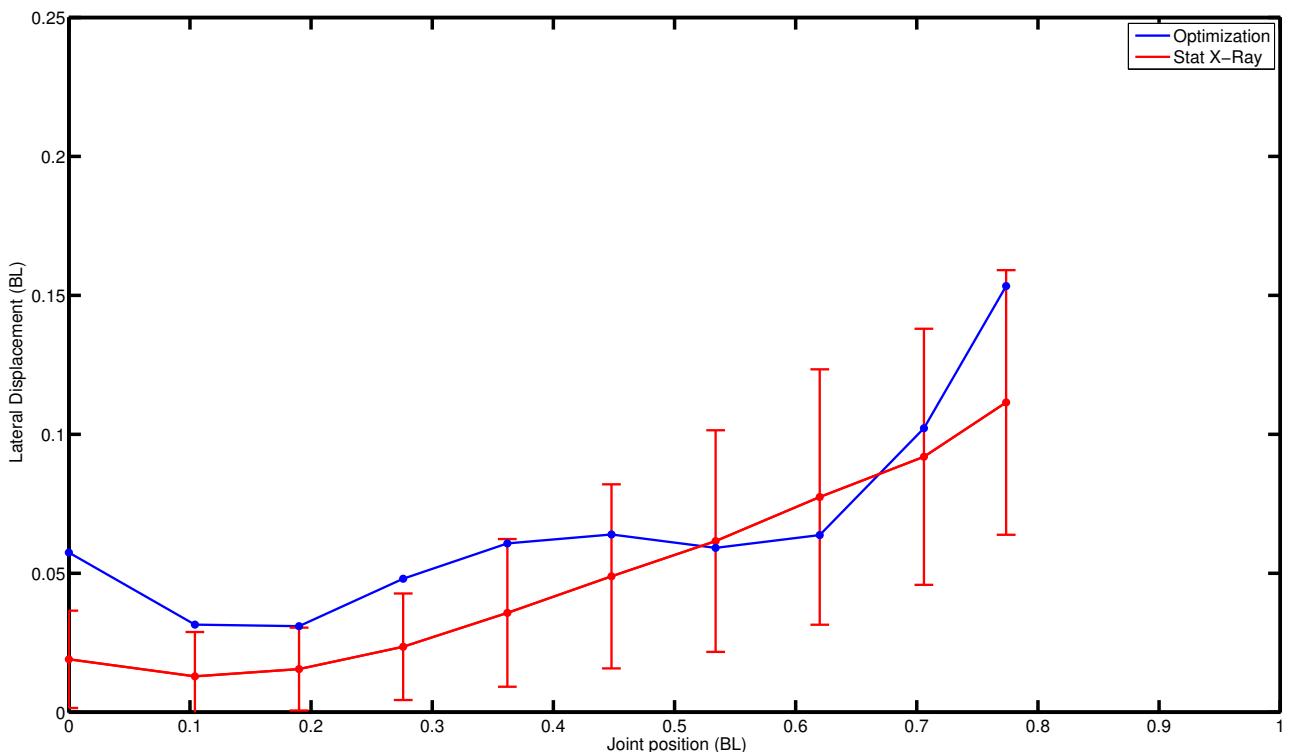


Figure 3.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_1Hz_4

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.057	NaN	NaN
Joint 1	0.032	0.107	NaN
Joint 2	0.031	0.118	-2.897
Joint 3	0.048	0.133	0.301
Joint 4	0.061	0.166	0.534
Joint 5	0.064	0.290	0.069
Joint 6	0.059	0.366	0.638
Joint 7	0.064	0.499	0.597
Joint 8	0.102	0.492	0.508
Joint 9	0.153	NaN	NaN

Table 3.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.286	0.928	3.250

Table 3.3: Speed data

3.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_4/BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_4.mp4

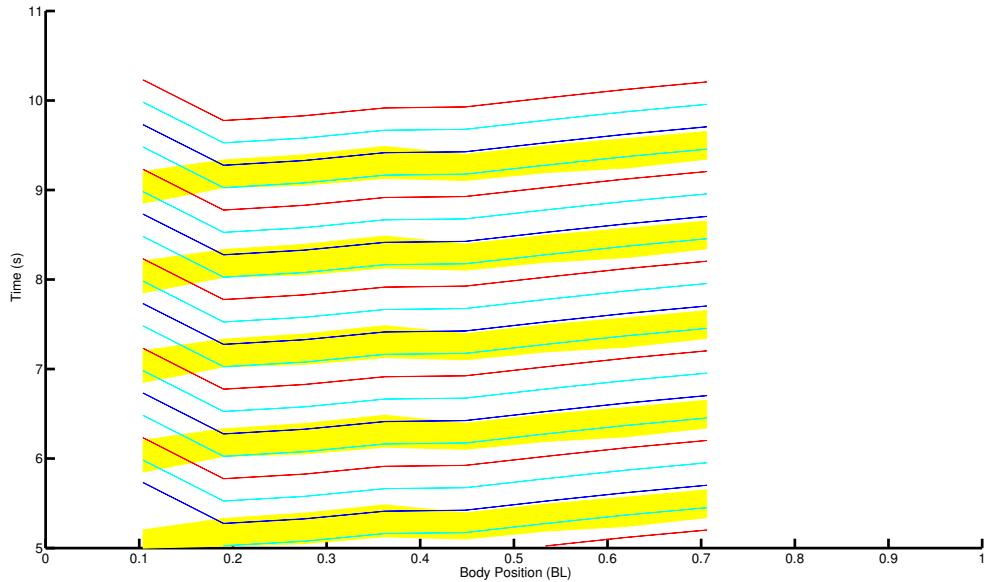


Figure 3.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_4

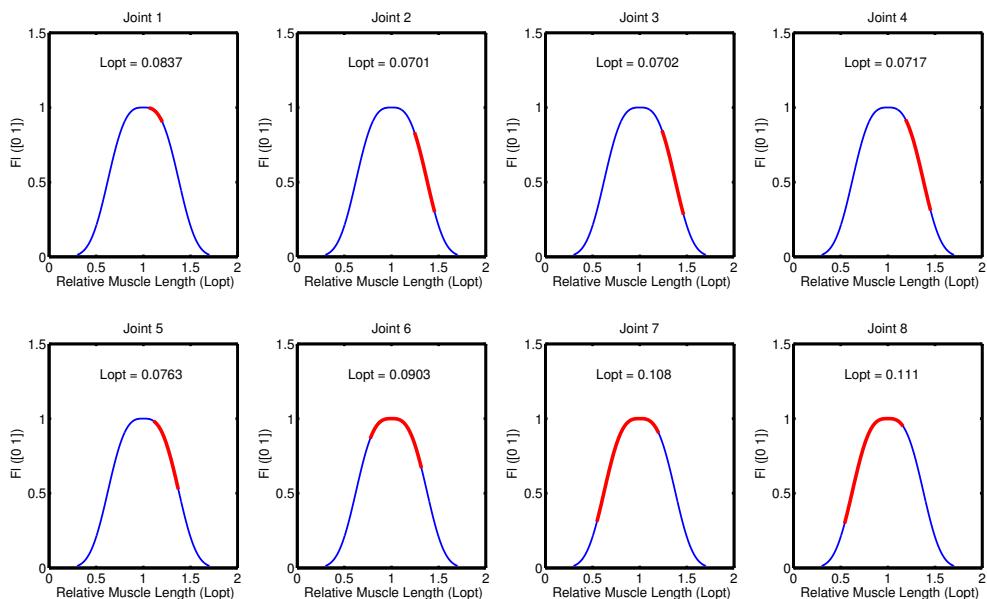


Figure 3.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_1Hz_4

3.3 Energy

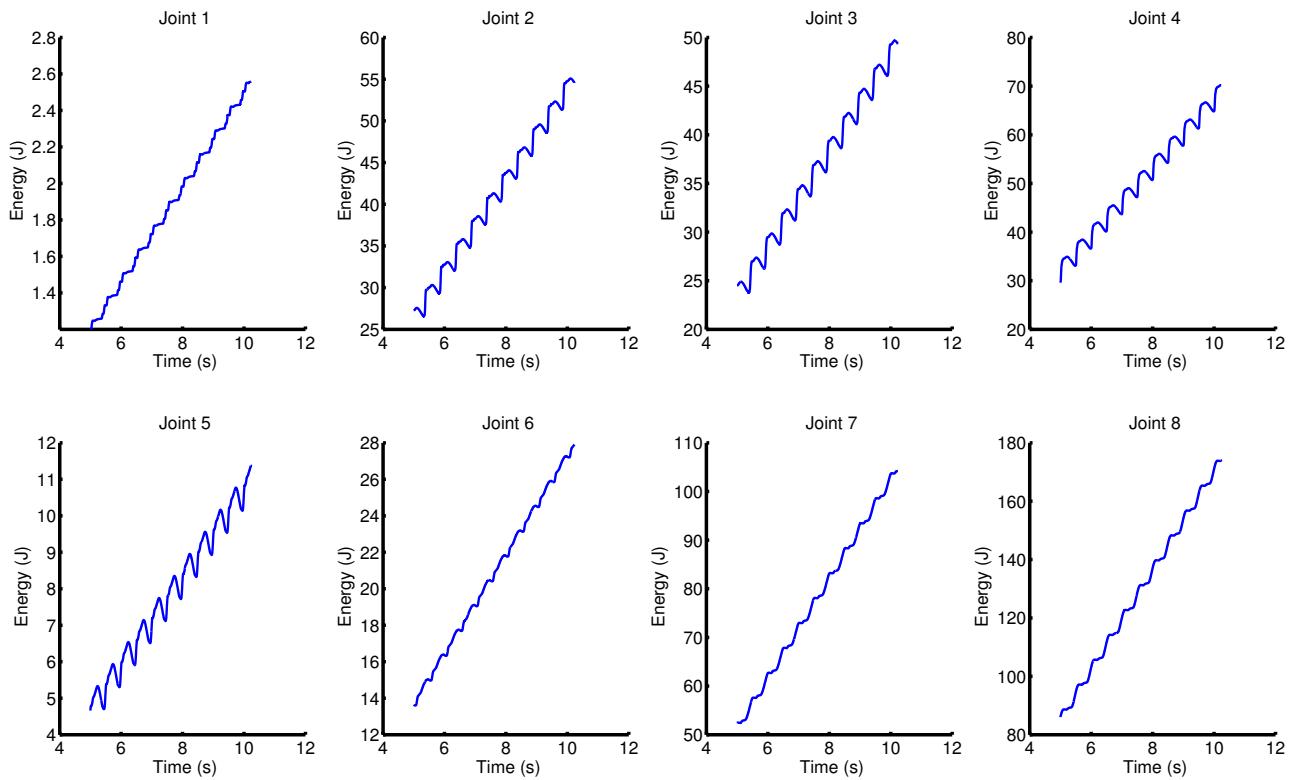


Figure 3.7: Energy_Opti_9seg_notaill_w62_Full_1Hz_4

4 Opti_9seg_notail_w62_Full_1Hz_5

4.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_5/Opti_9seg_notail_w62_Full_1Hz_5.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	1.714	182.446	94.696	159.100	44.222	11.715	25.095	100.147
Lopt (m)	0.070	0.070	0.070	0.071	0.088	0.077	0.107	0.116
r (m)	0.138	0.140	0.130	0.108	0.138	0.112	0.140	0.139
TimeLag (s)	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669
error	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Fitness	4.086	4.086	4.086	4.086	4.086	4.086	4.086	4.086

Table 4.1: Optimised Parameters

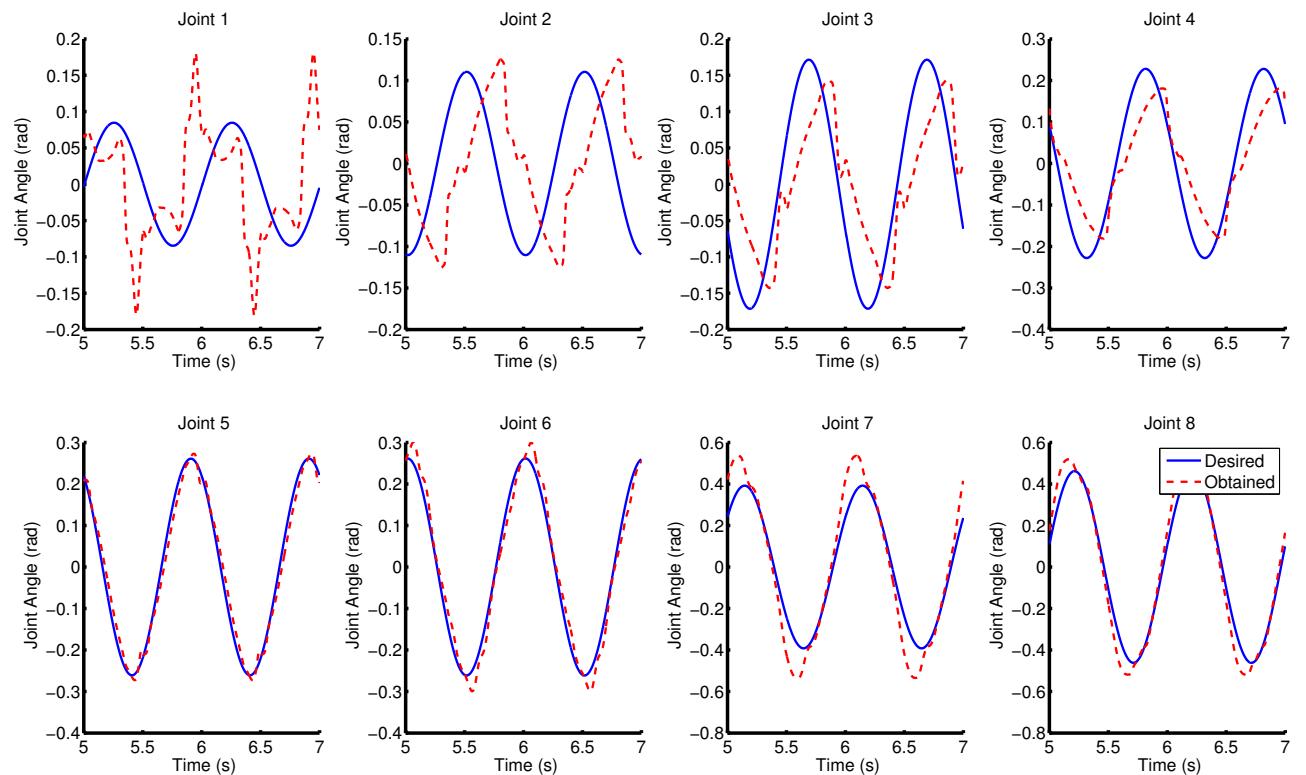


Figure 4.1: AngleDiff_Opti_9seg_notail_w62_Full_1Hz_5

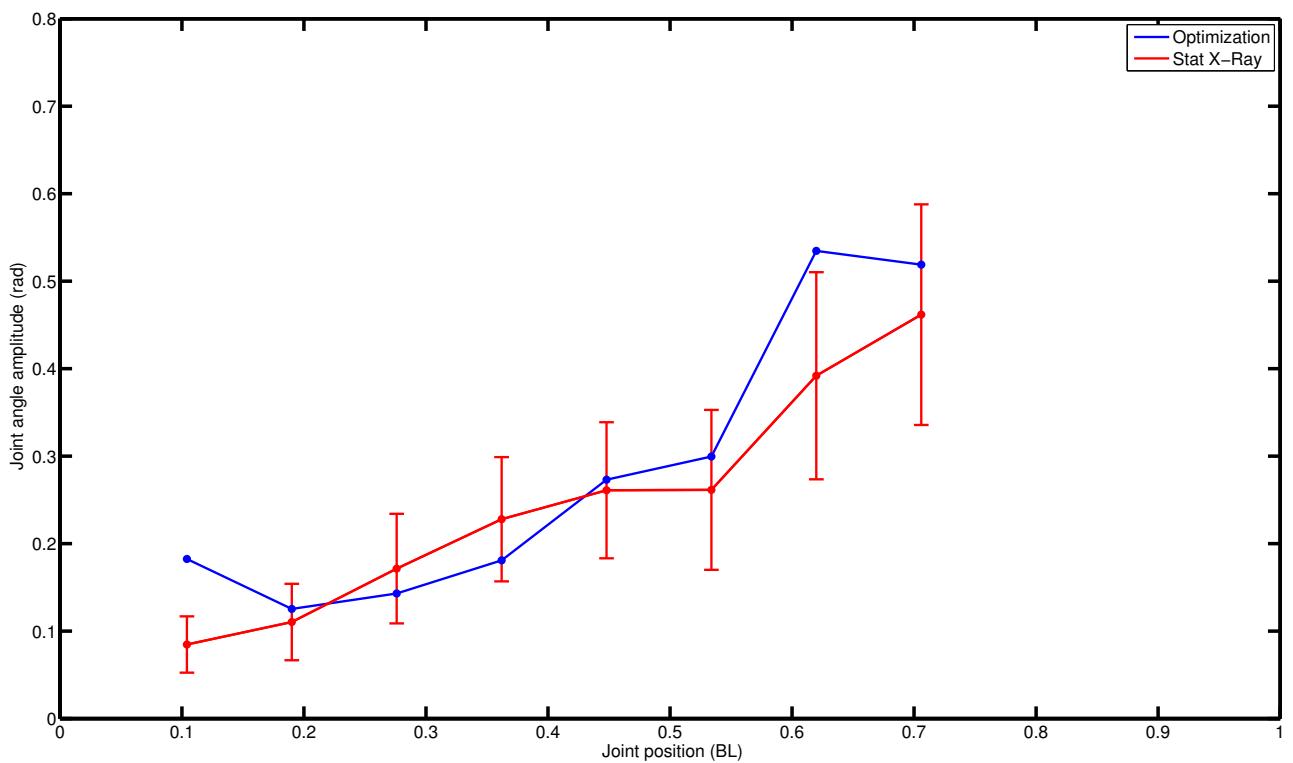


Figure 4.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_1Hz_5

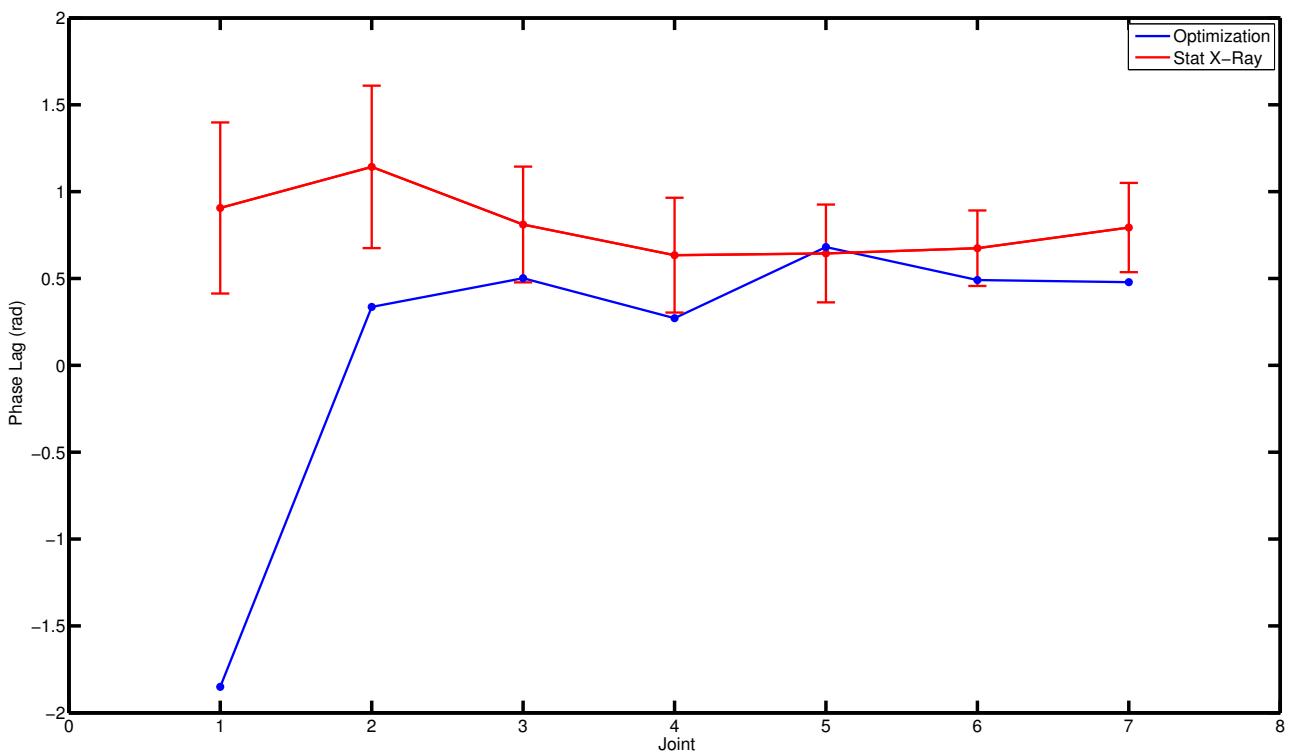


Figure 4.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_1Hz_5

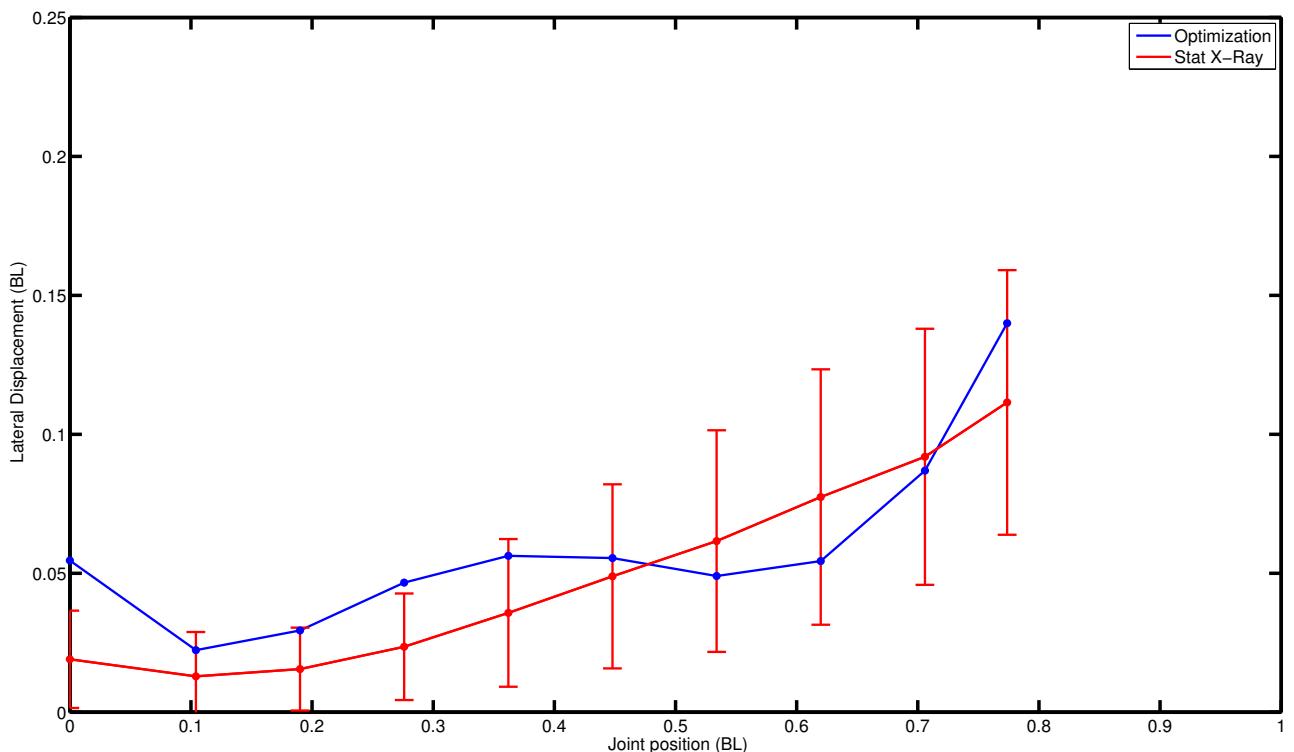


Figure 4.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_1Hz_5

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.055	NaN	NaN
Joint 1	0.022	0.182	NaN
Joint 2	0.029	0.125	-1.851
Joint 3	0.047	0.143	0.336
Joint 4	0.056	0.181	0.502
Joint 5	0.055	0.273	0.271
Joint 6	0.049	0.300	0.681
Joint 7	0.054	0.535	0.491
Joint 8	0.087	0.519	0.479
Joint 9	0.140	NaN	NaN

Table 4.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.275	1.408	5.116

Table 4.3: Speed data

4.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_1Hz_5/BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_5.mp4

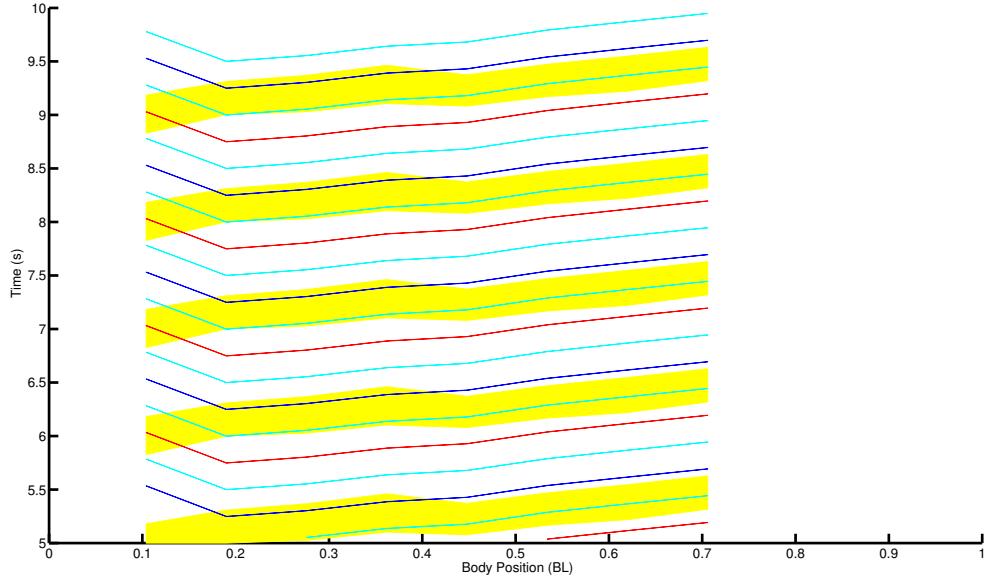


Figure 4.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_1Hz_5

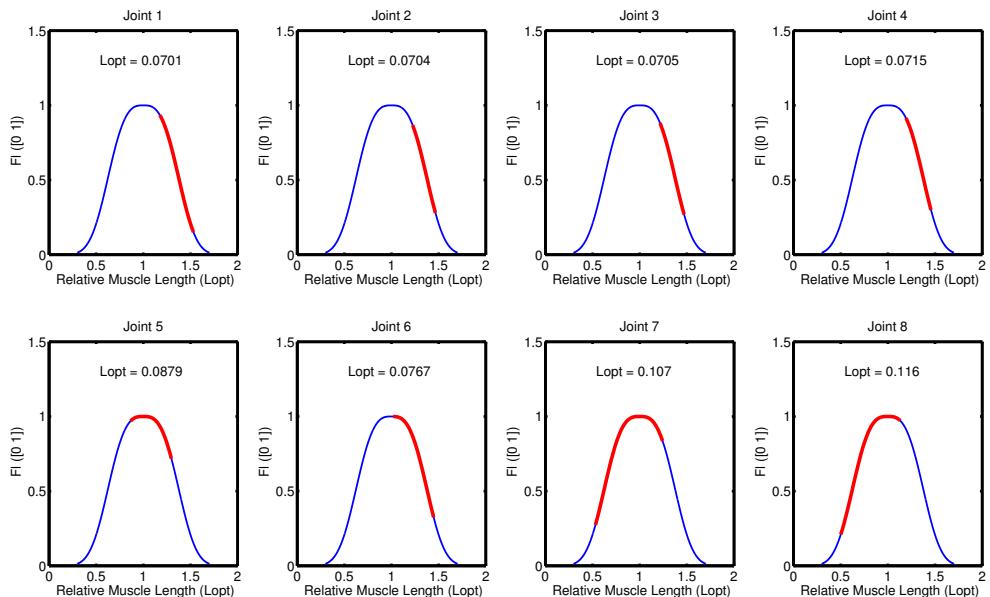


Figure 4.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_1Hz_5

4.3 Energy

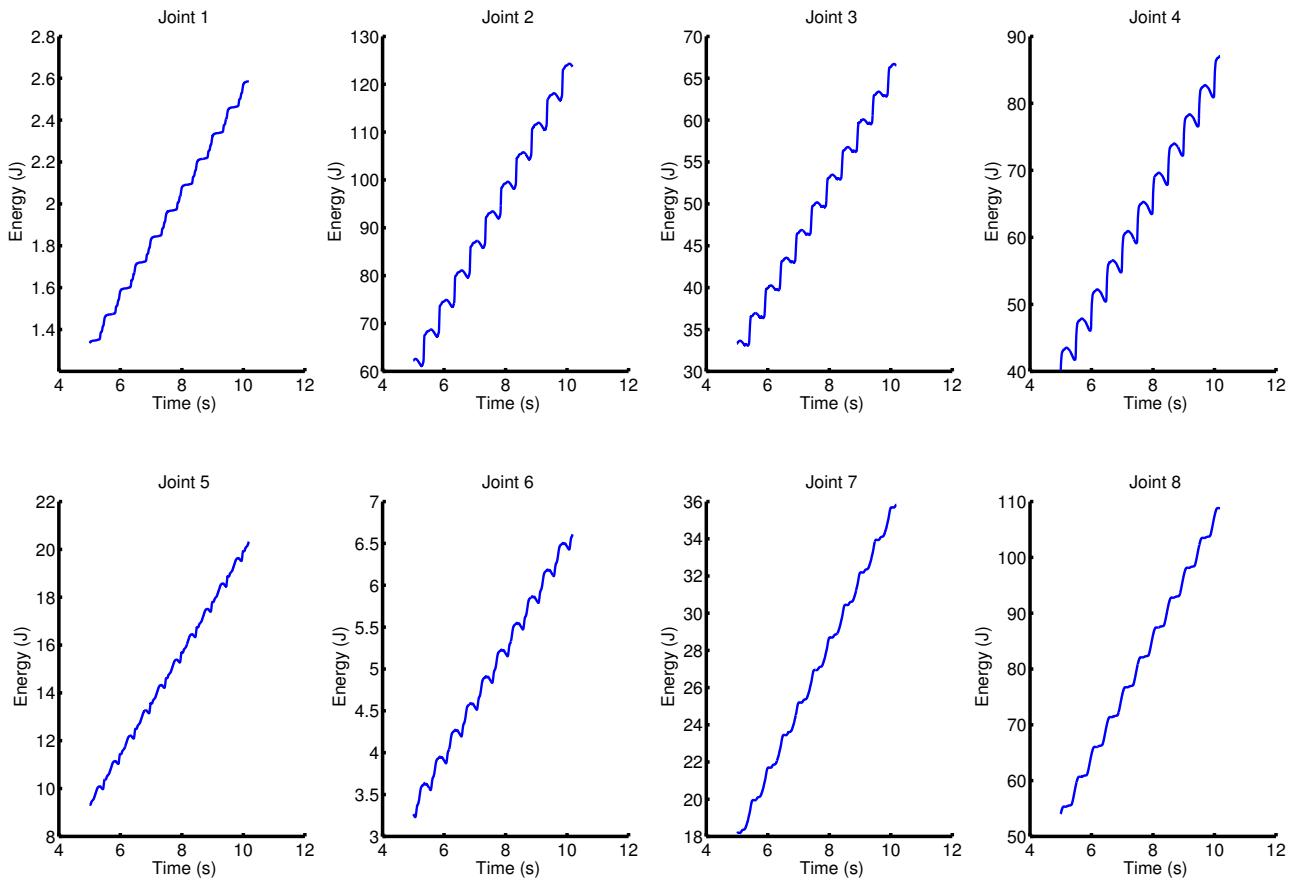


Figure 4.7: Energy_Opti_9seg_notail_w62_Full_1Hz_5

5 Opti_9seg_tail_w62_Full_1Hz_1

5.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_1/Opti_9seg_tail_w62_Full_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	75.140	4.337	115.593	121.150	74.917	114.434	114.134	120.578
Lopt (m)	0.070	0.072	0.075	0.076	0.094	0.094	0.097	0.100
r (m)	0.136	0.132	0.124	0.099	0.098	0.133	0.106	0.113
TimeLag (s)	0.716	0.716	0.716	0.716	0.716	0.716	0.716	0.716
error	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
Fitness	7.861	7.861	7.861	7.861	7.861	7.861	7.861	7.861

Table 5.1: Optimised Parameters

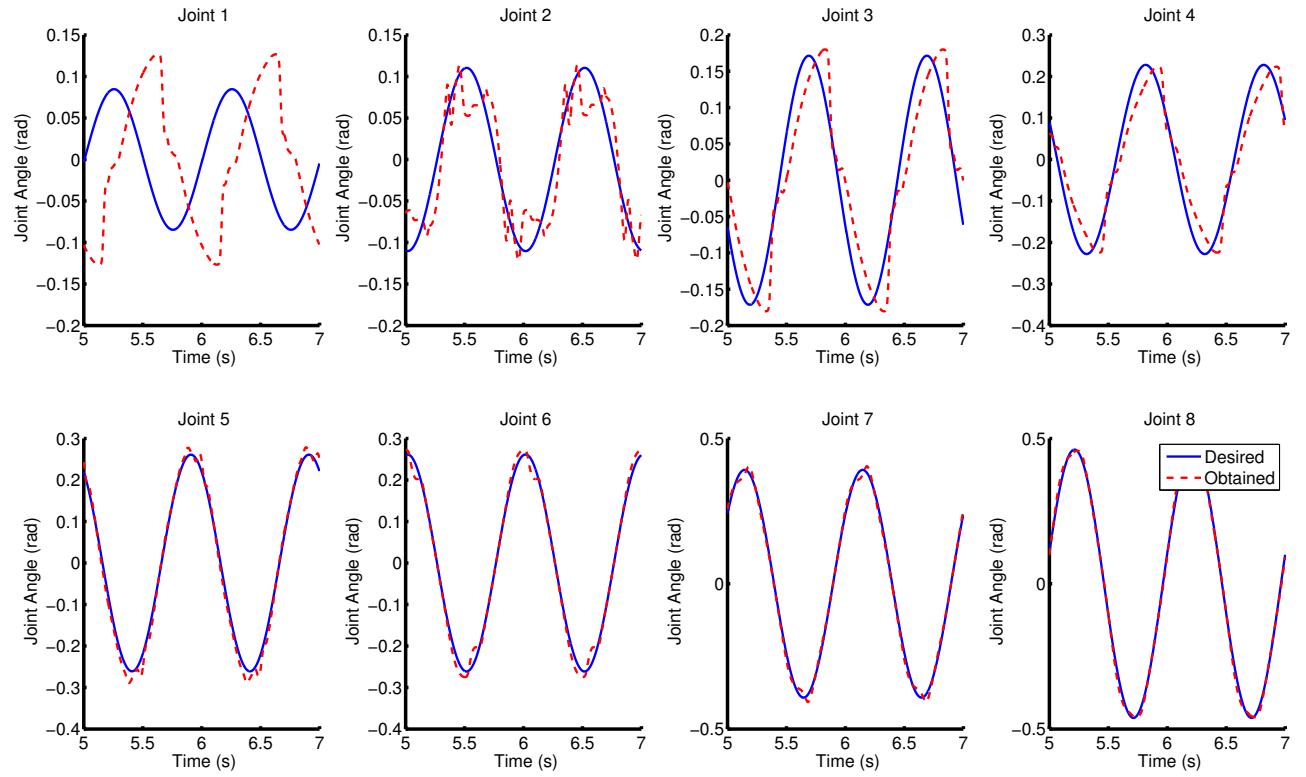


Figure 5.1: AngleDiff_Opti_9seg_tail_w62_Full_1Hz_1

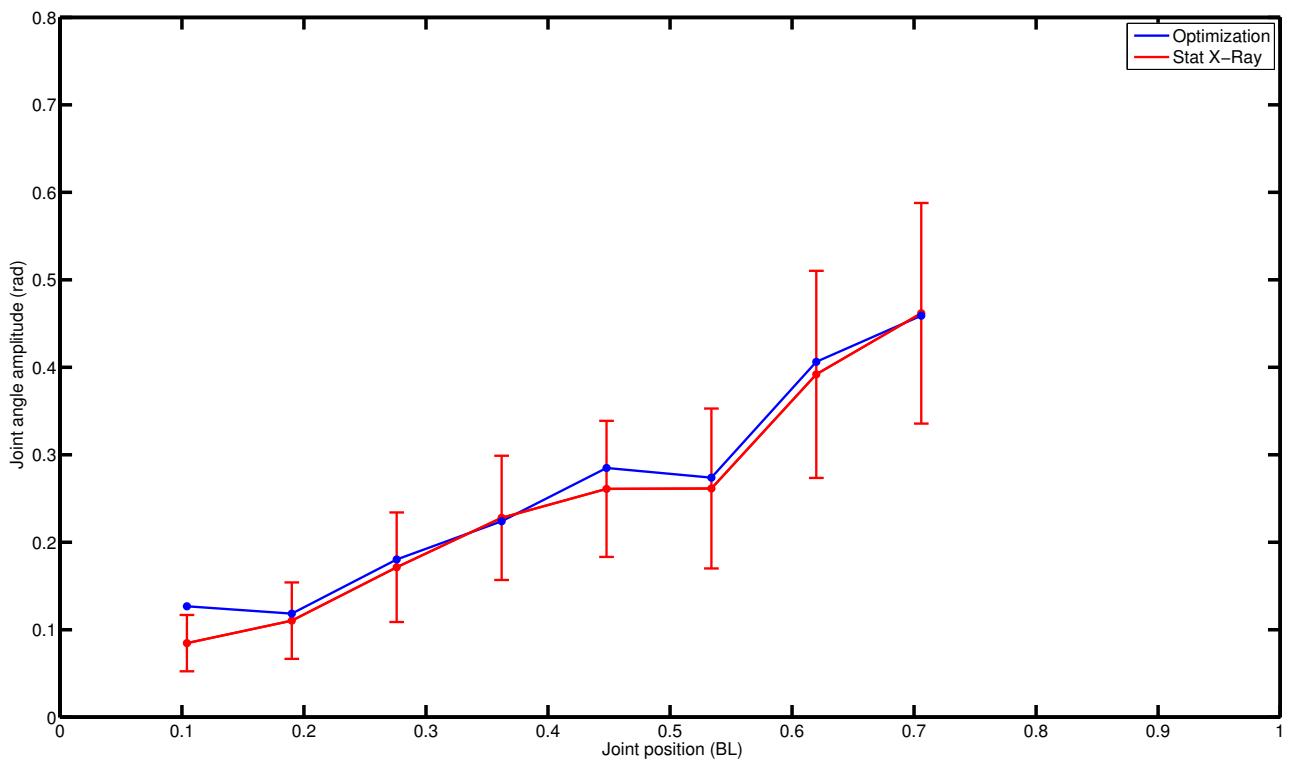


Figure 5.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_1Hz_1

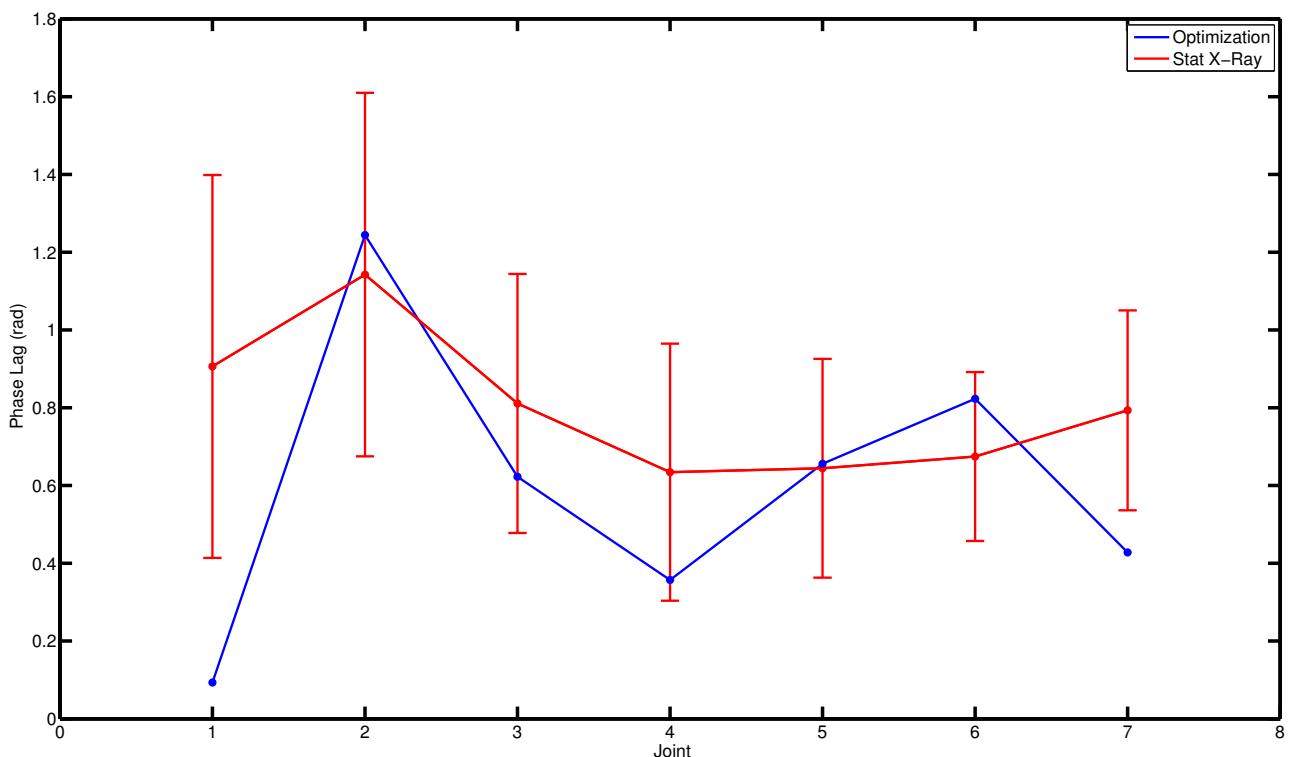


Figure 5.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_1Hz_1

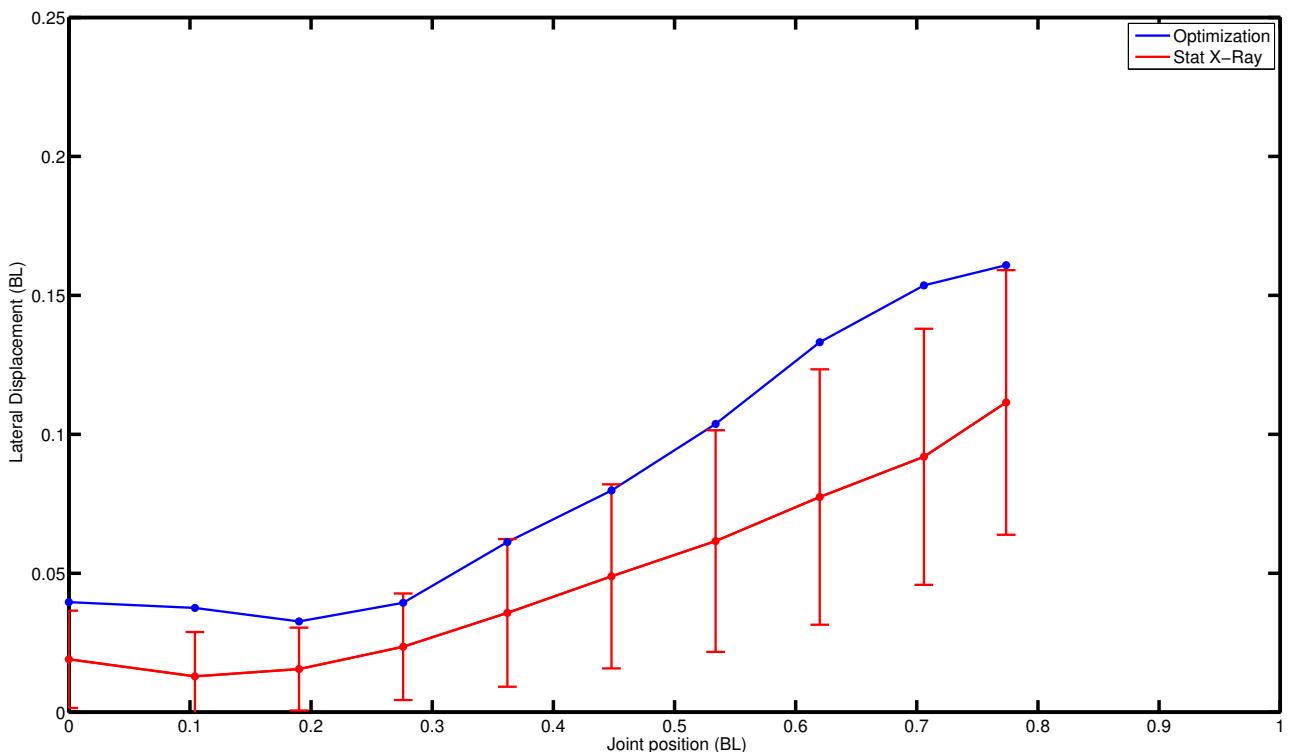


Figure 5.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.040	NaN	NaN
Joint 1	0.038	0.127	NaN
Joint 2	0.033	0.118	0.093
Joint 3	0.039	0.180	1.244
Joint 4	0.061	0.224	0.622
Joint 5	0.080	0.285	0.357
Joint 6	0.104	0.274	0.656
Joint 7	0.133	0.406	0.823
Joint 8	0.154	0.459	0.428
Joint 9	0.161	NaN	NaN

Table 5.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.584	0.949	1.626

Table 5.3: Speed data

5.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_1.mp4

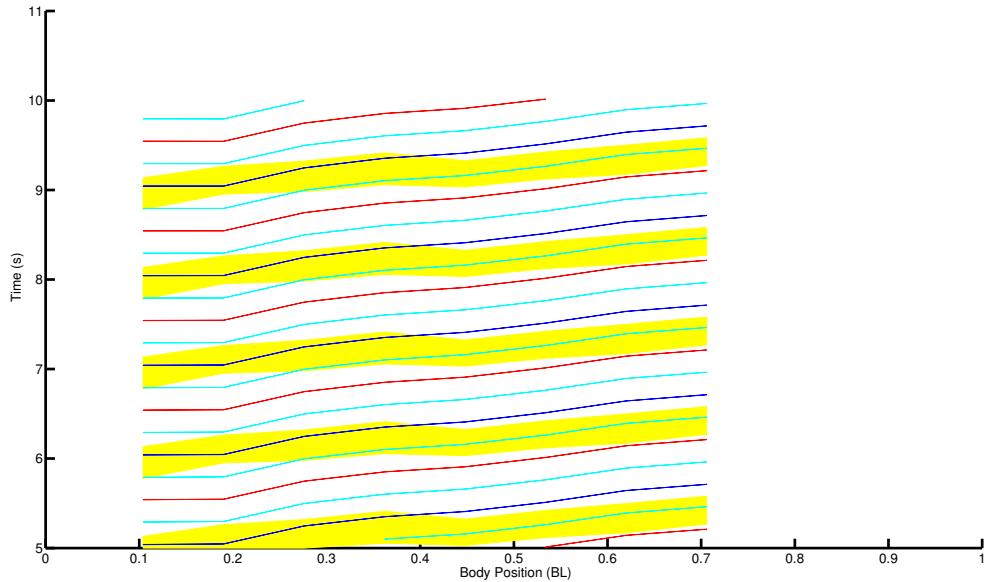


Figure 5.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_1

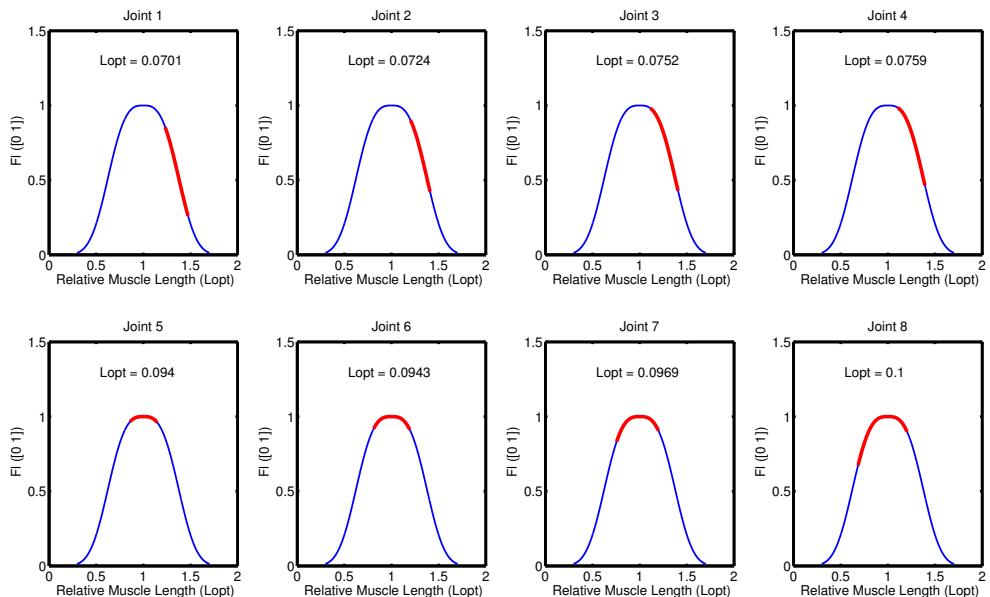


Figure 5.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_1Hz_1

5.3 Energy

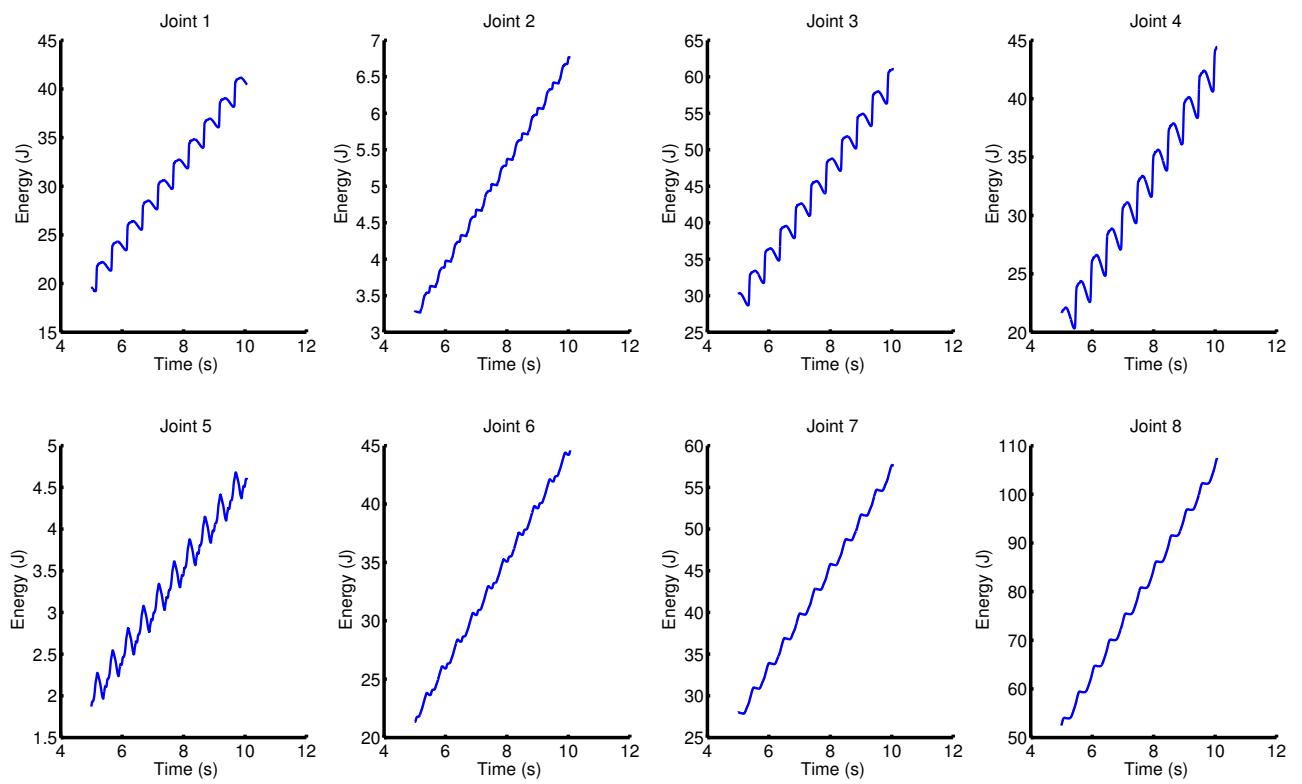


Figure 5.7: Energy_Opti_9seg_tail_w62_Full_1Hz_1

6 Opti_9seg_tail_w62_Full_1Hz_2

6.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_2/Opti_9seg_tail_w62_Full_1Hz_2.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	182.367	4.776	193.689	187.303	68.481	113.315	117.791	156.856
Lopt (m)	0.070	0.071	0.071	0.075	0.096	0.095	0.095	0.105
r (m)	0.131	0.118	0.093	0.086	0.115	0.137	0.096	0.122
TimeLag (s)	0.714	0.714	0.714	0.714	0.714	0.714	0.714	0.714
error	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
Fitness	7.876	7.876	7.876	7.876	7.876	7.876	7.876	7.876

Table 6.1: Optimised Parameters

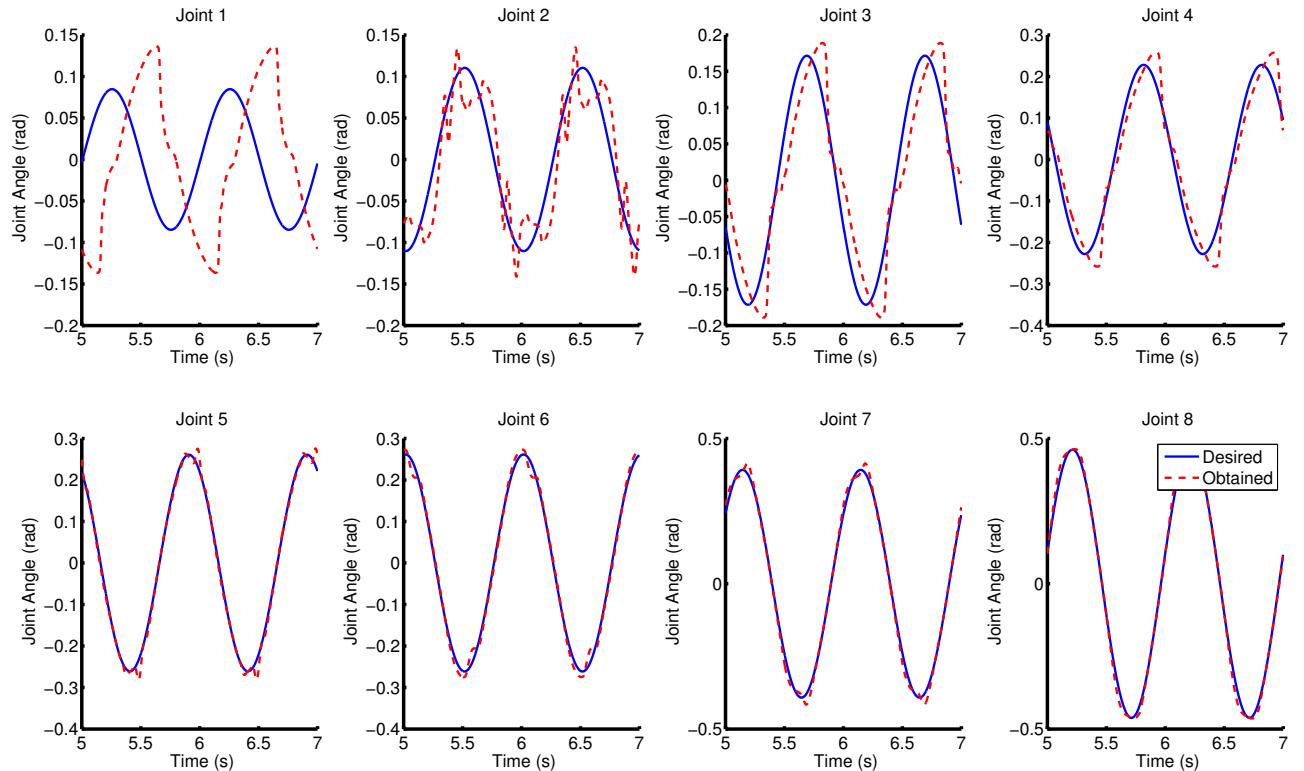


Figure 6.1: AngleDiff_Opti_9seg_tail_w62_Full_1Hz_2

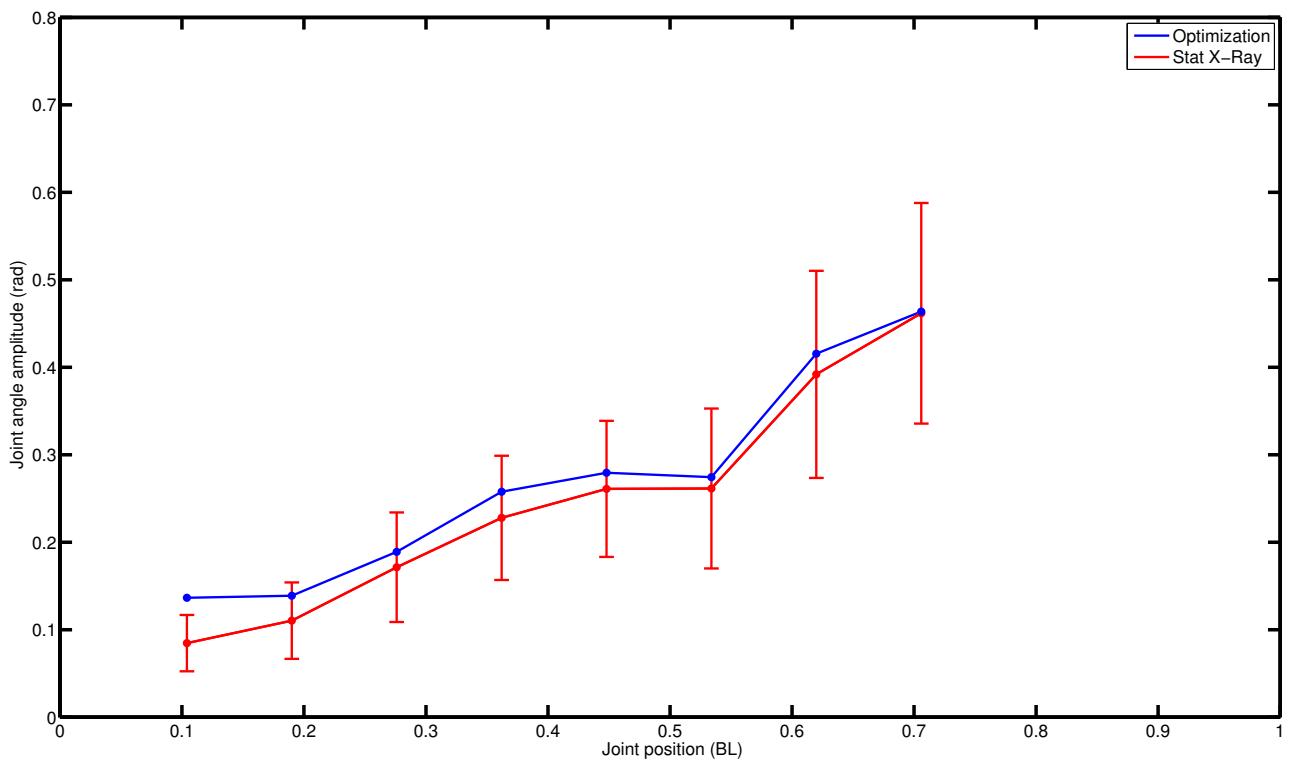


Figure 6.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_1Hz_2

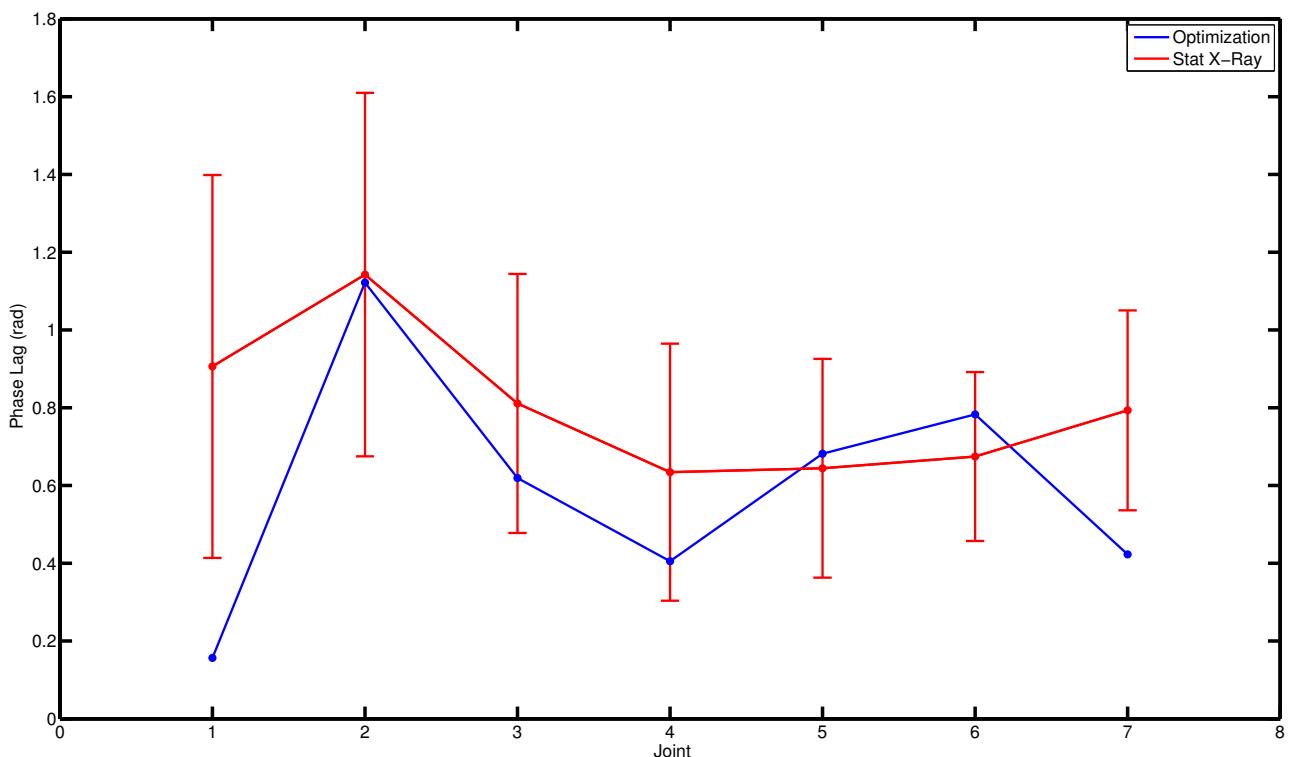


Figure 6.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_1Hz_2

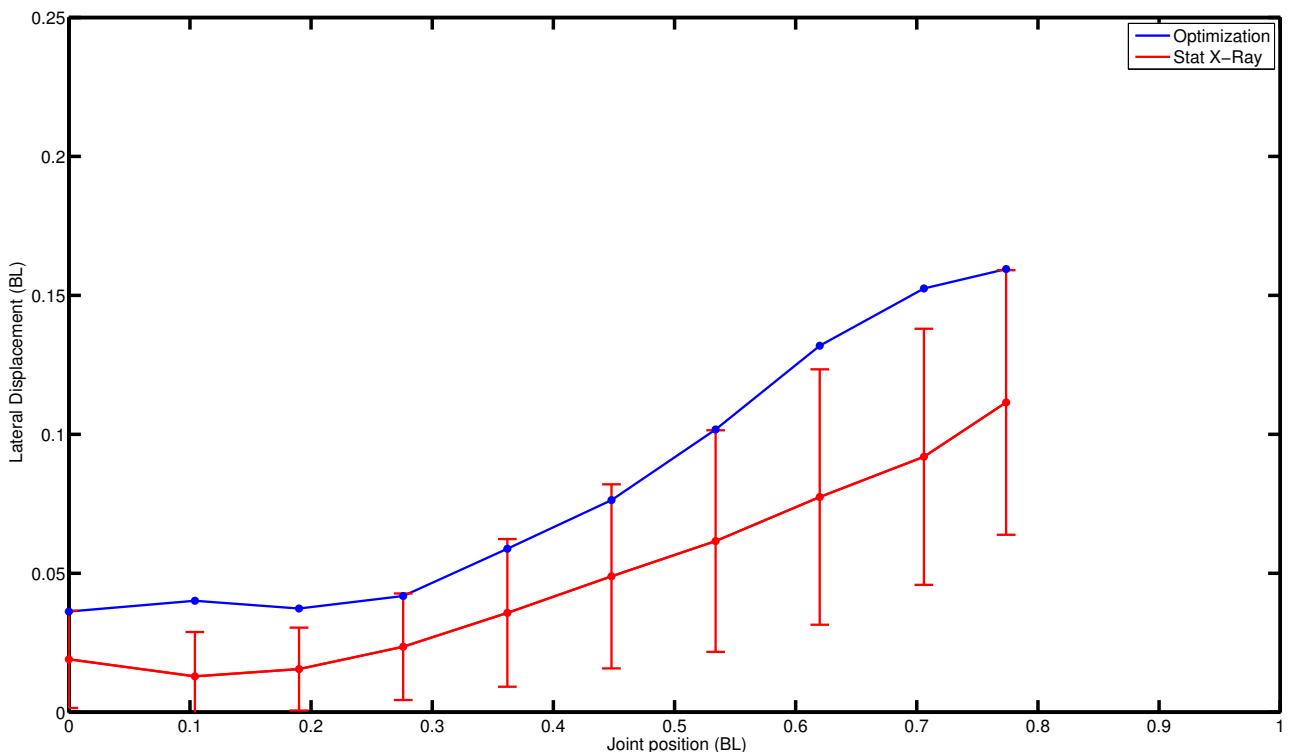


Figure 6.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_1Hz_2

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.036	NaN	NaN
Joint 1	0.040	0.137	NaN
Joint 2	0.037	0.139	0.156
Joint 3	0.042	0.189	1.122
Joint 4	0.059	0.258	0.619
Joint 5	0.076	0.279	0.405
Joint 6	0.102	0.274	0.682
Joint 7	0.132	0.416	0.783
Joint 8	0.152	0.464	0.423
Joint 9	0.159	NaN	NaN

Table 6.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.587	1.010	1.721

Table 6.3: Speed data

6.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_2/BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_2.mp4

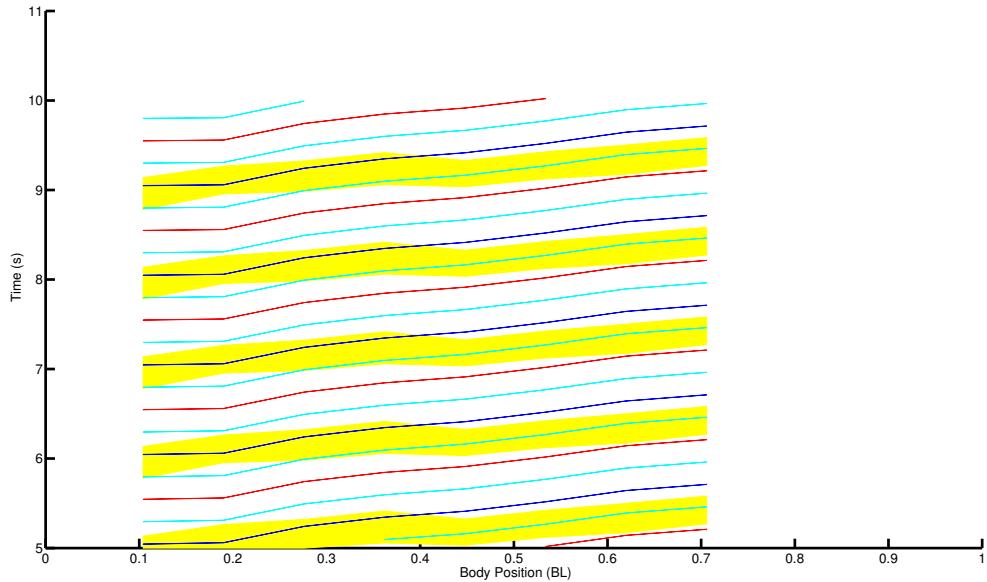


Figure 6.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_2

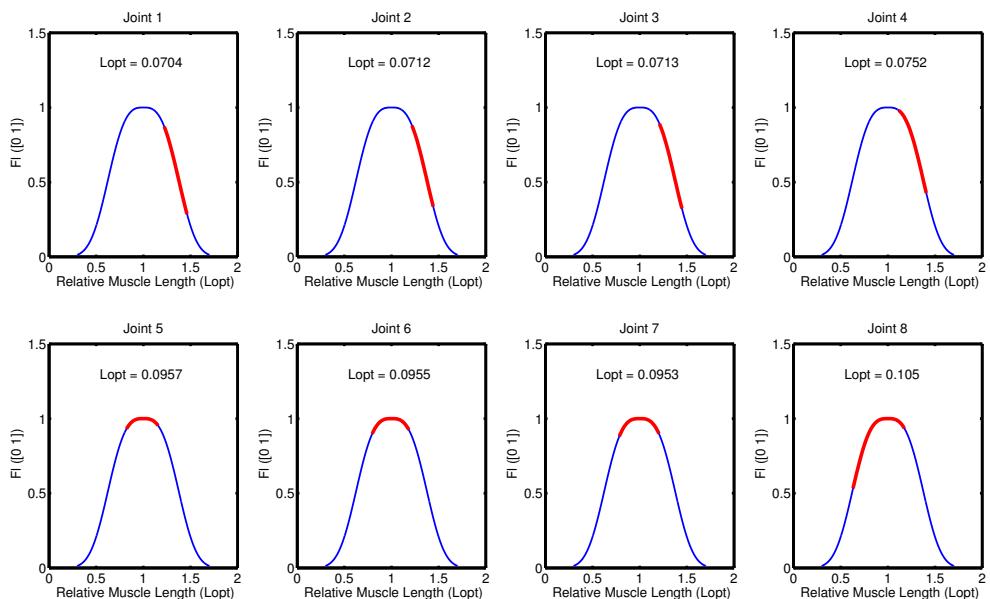


Figure 6.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_1Hz_2

6.3 Energy

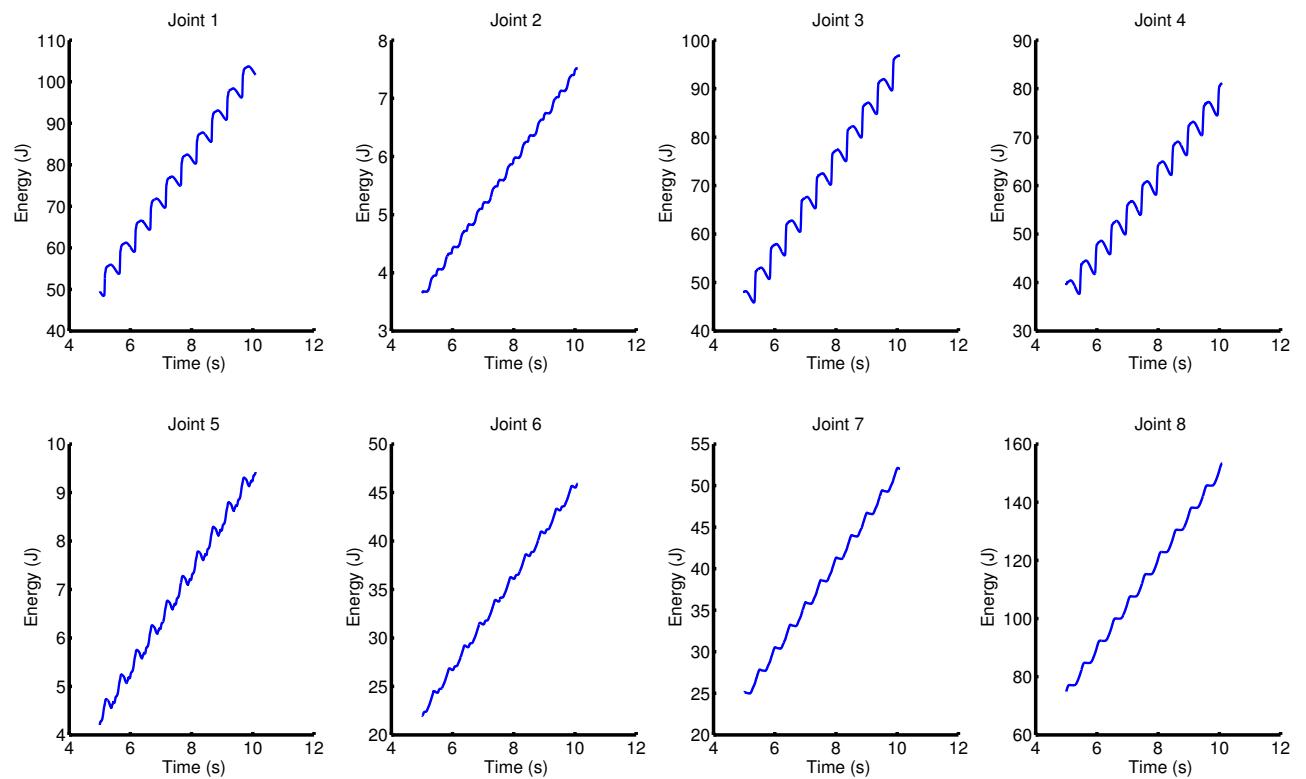


Figure 6.7: Energy_Opti_9seg_tail_w62_Full_1Hz_2

7 Opti_9seg_tail_w62_Full_1Hz_3

7.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_3/Opti_9seg_tail_w62_Full_1Hz_3.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	39.760	3.458	172.256	158.926	60.485	91.042	114.509	115.175
Lopt (m)	0.070	0.070	0.071	0.078	0.104	0.099	0.107	0.108
r (m)	0.138	0.137	0.082	0.095	0.136	0.138	0.135	0.138
TimeLag (s)	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743
error	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
Fitness	9.391	9.391	9.391	9.391	9.391	9.391	9.391	9.391

Table 7.1: Optimised Parameters

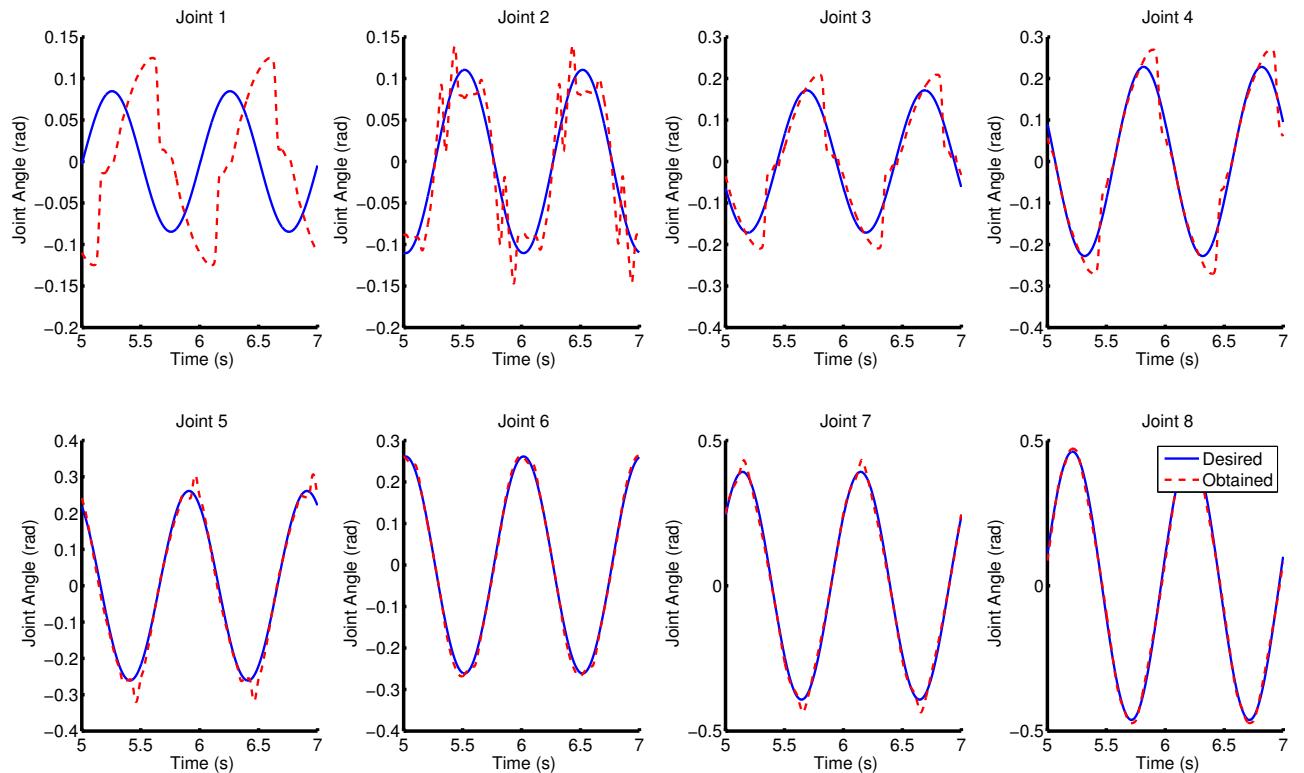


Figure 7.1: AngleDiff_Opti_9seg_tail_w62_Full_1Hz_3

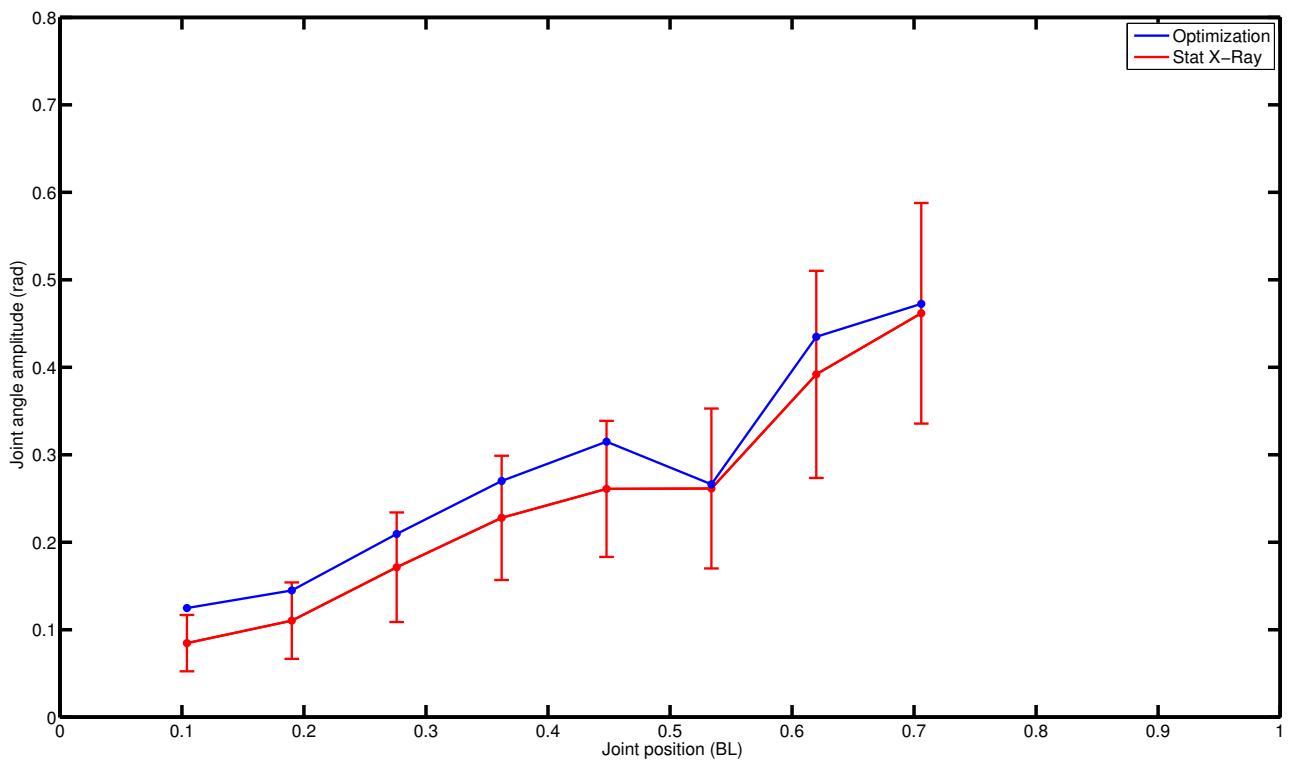


Figure 7.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_1Hz_3

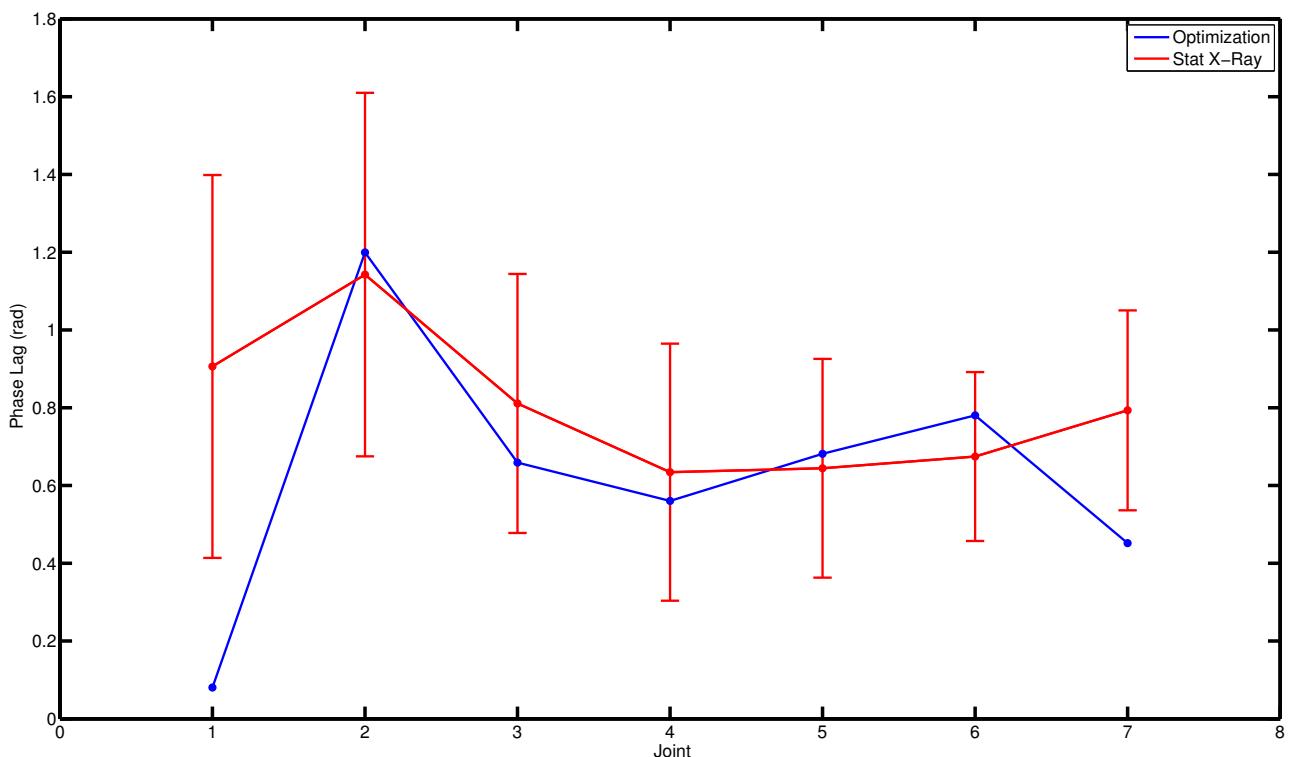


Figure 7.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_1Hz_3

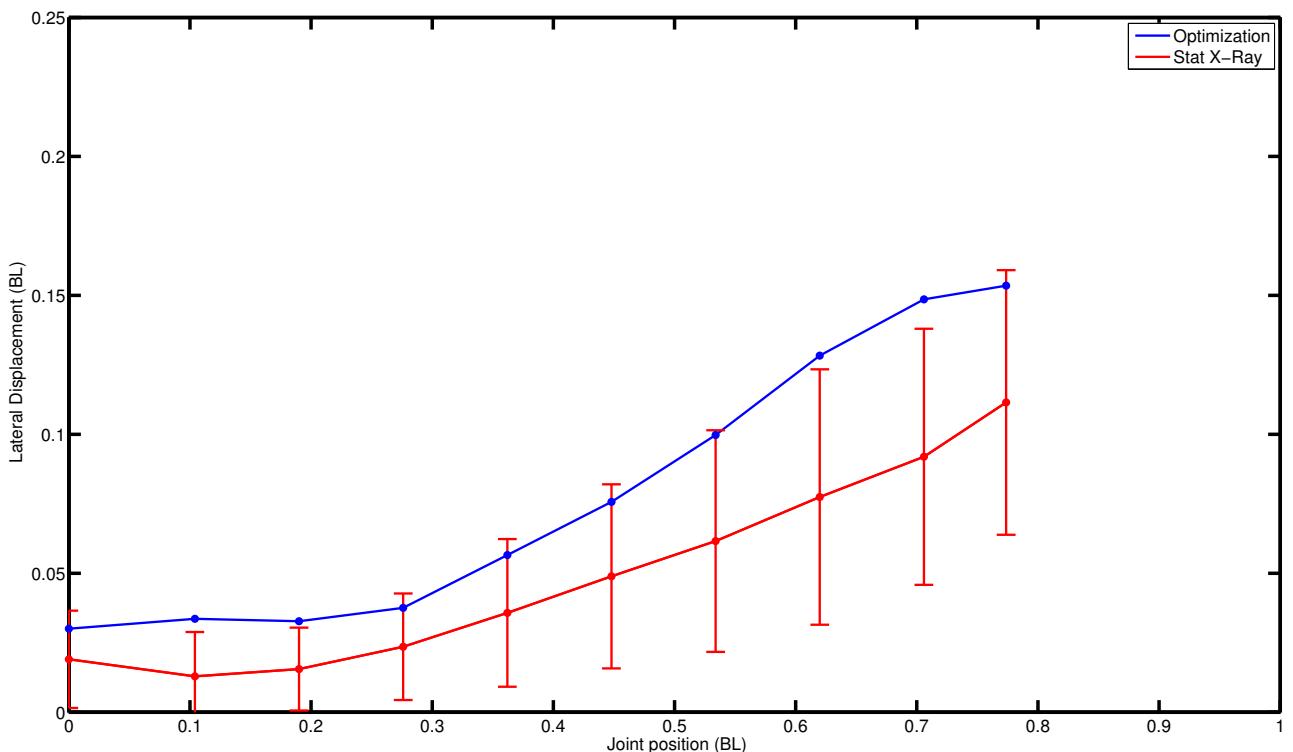


Figure 7.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_1Hz_3

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.030	NaN	NaN
Joint 1	0.034	0.125	NaN
Joint 2	0.033	0.145	0.080
Joint 3	0.038	0.210	1.199
Joint 4	0.057	0.270	0.659
Joint 5	0.076	0.315	0.560
Joint 6	0.100	0.266	0.681
Joint 7	0.128	0.435	0.780
Joint 8	0.149	0.473	0.452
Joint 9	0.153	NaN	NaN

Table 7.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.569	0.971	1.706

Table 7.3: Speed data

7.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_3/BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_3.mp4

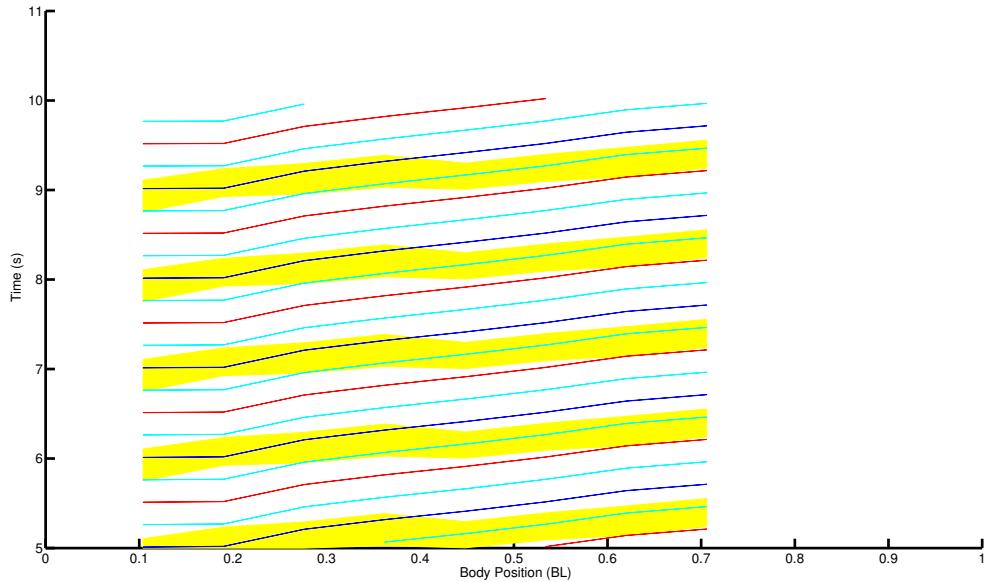


Figure 7.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_3

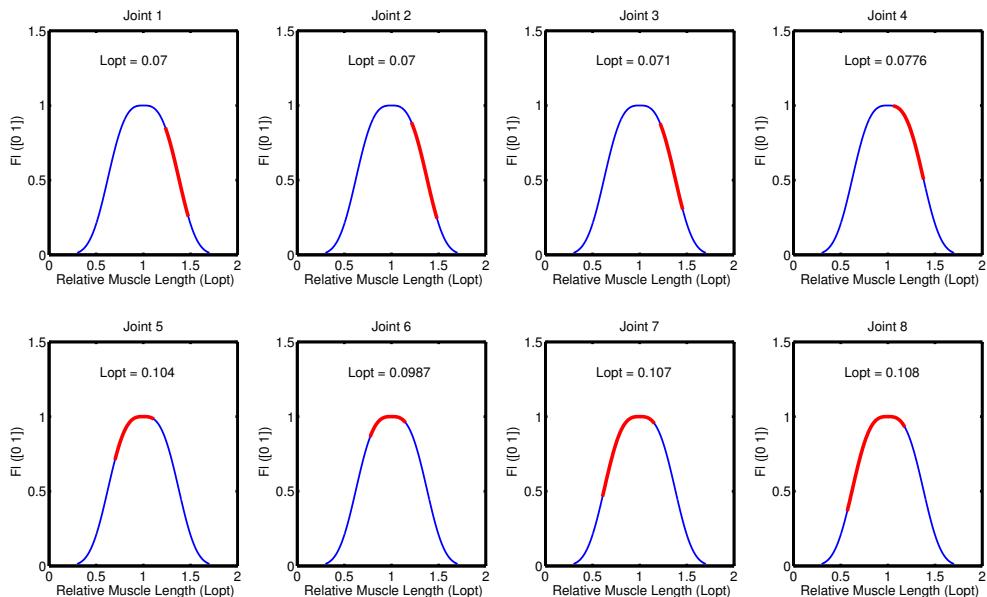


Figure 7.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_1Hz_3

7.3 Energy

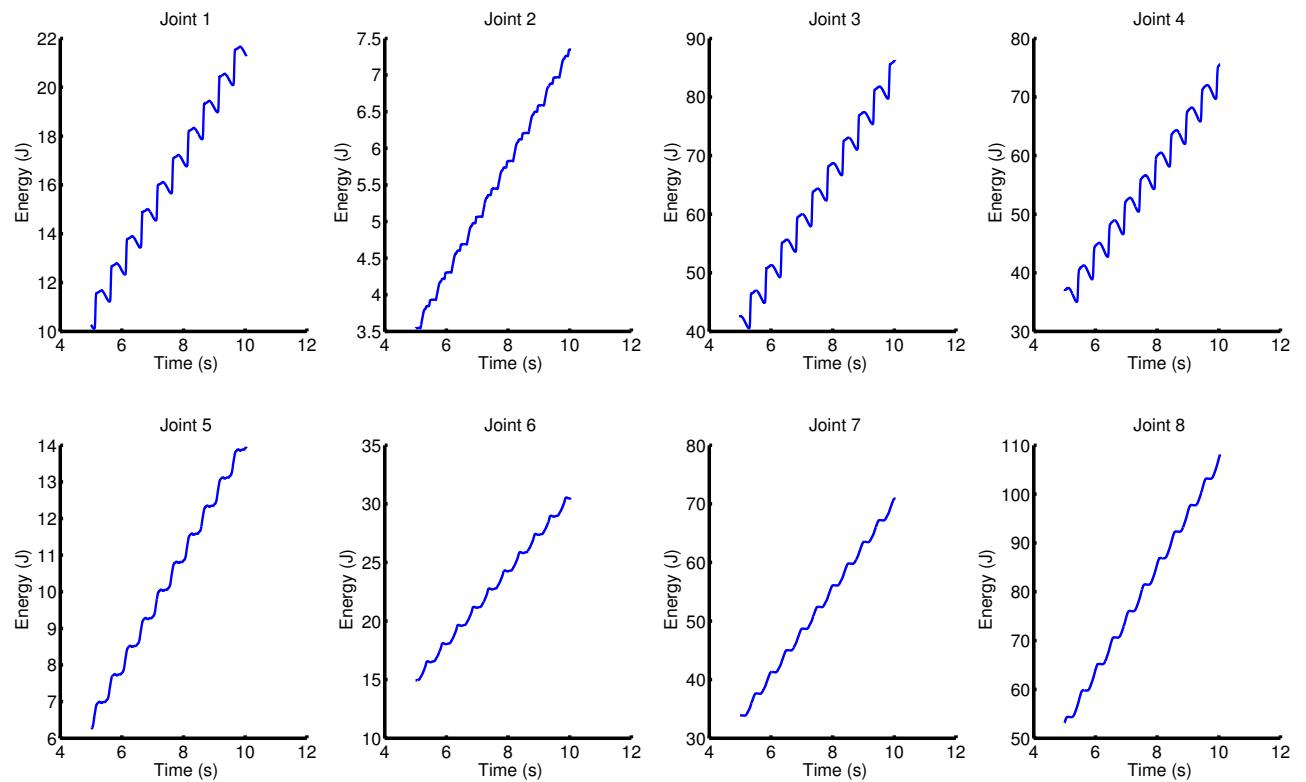


Figure 7.7: Energy_Opti_9seg_tail_w62_Full_1Hz_3

8 Opti_9seg_tail_w62_Full_1Hz_4

8.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_4/Opti_9seg_tail_w62_Full_1Hz_4.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	92.306	140.994	83.388	150.802	56.071	76.728	77.268	70.926
Lopt (m)	0.070	0.071	0.078	0.082	0.092	0.095	0.096	0.096
r (m)	0.135	0.133	0.134	0.121	0.088	0.130	0.106	0.104
TimeLag (s)	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747
error	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
Fitness	7.407	7.407	7.407	7.407	7.407	7.407	7.407	7.407

Table 8.1: Optimised Parameters

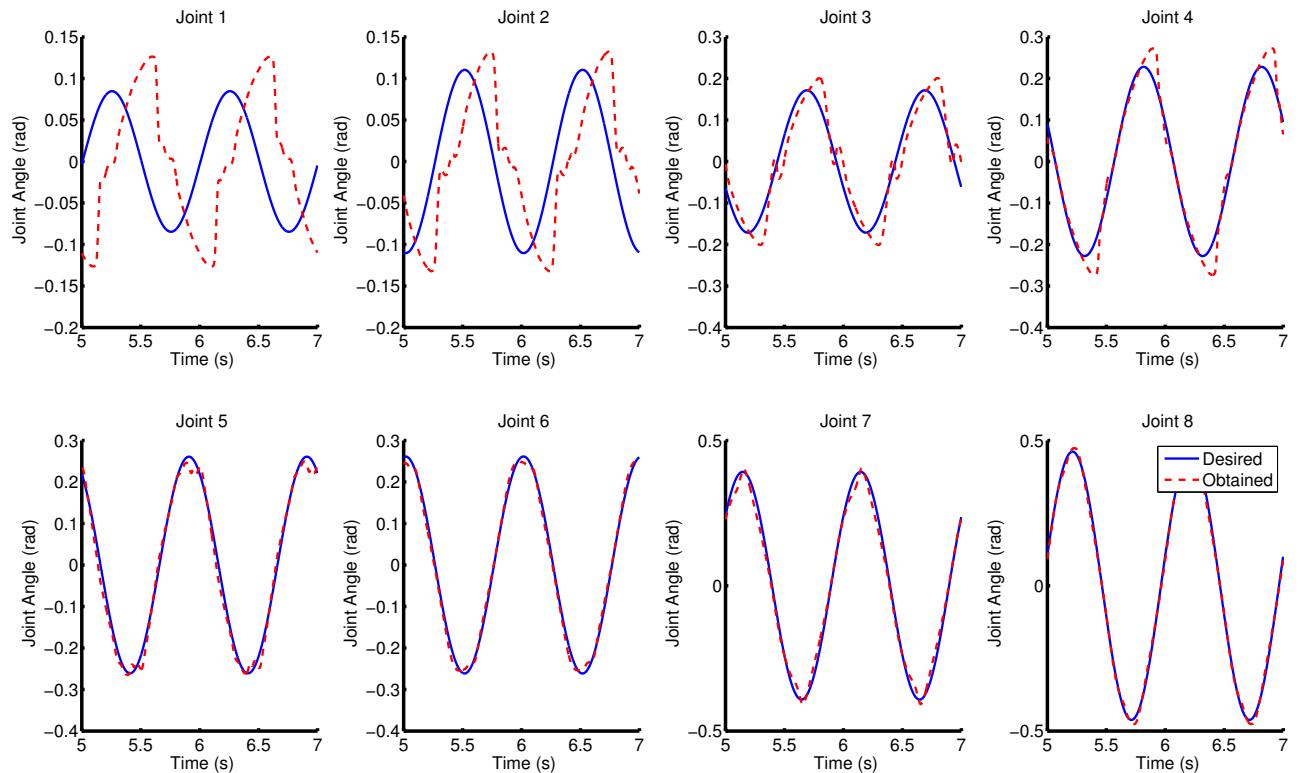


Figure 8.1: AngleDiff_Opti_9seg_tail_w62_Full_1Hz_4

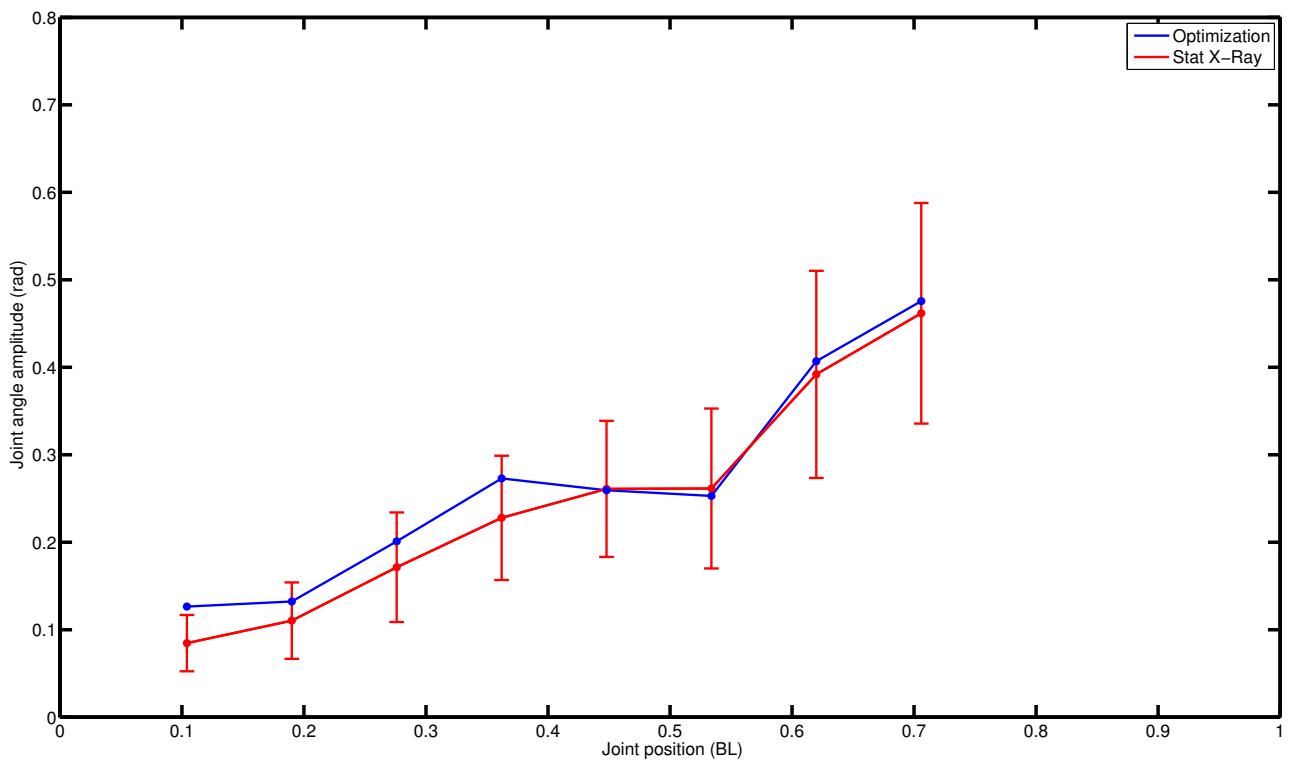


Figure 8.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_1Hz_4

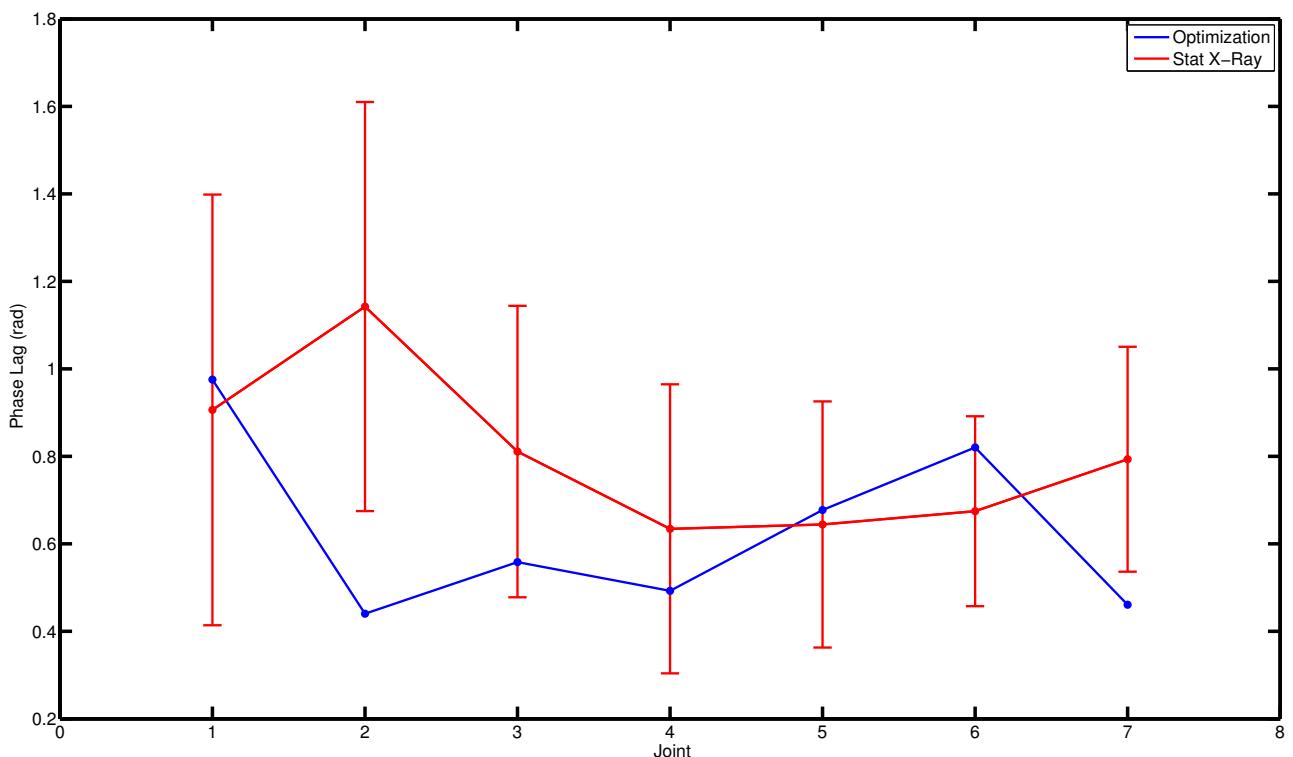


Figure 8.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_1Hz_4

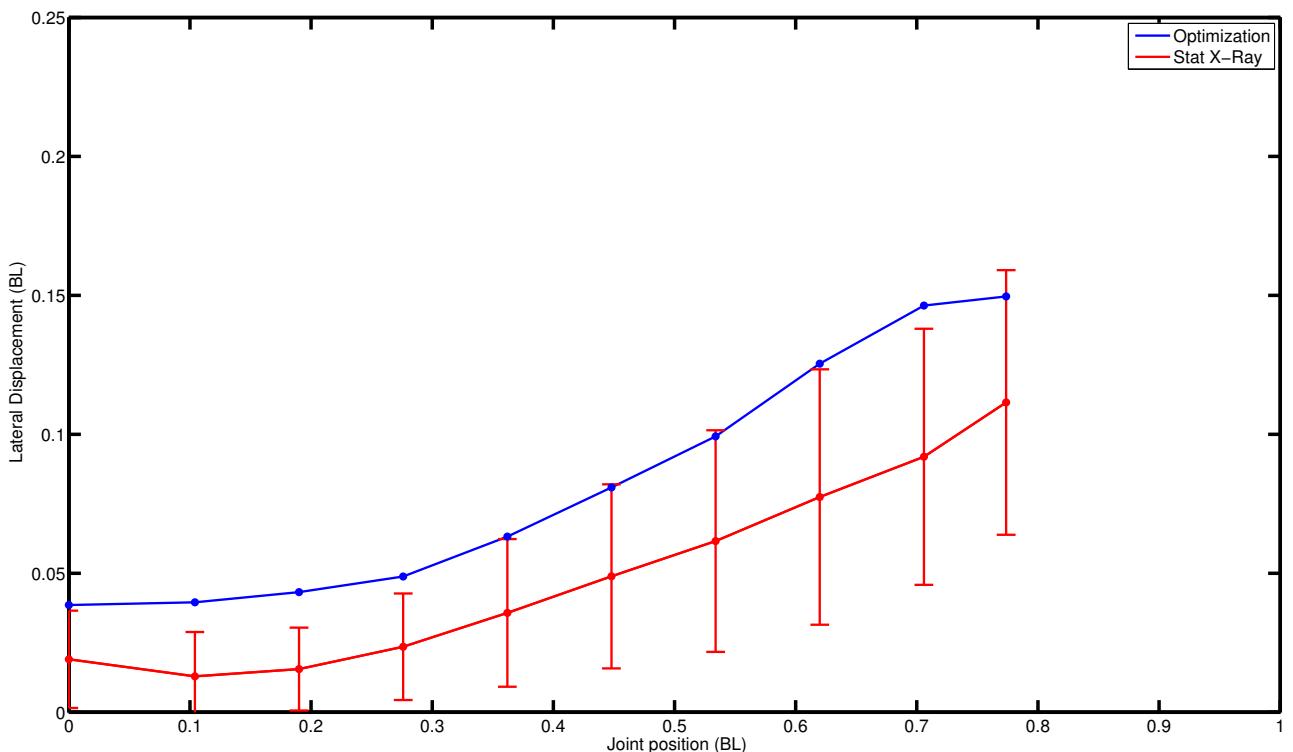


Figure 8.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_1Hz_4

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.039	NaN	NaN
Joint 1	0.040	0.126	NaN
Joint 2	0.043	0.132	0.975
Joint 3	0.049	0.201	0.440
Joint 4	0.063	0.273	0.558
Joint 5	0.081	0.259	0.493
Joint 6	0.099	0.253	0.677
Joint 7	0.125	0.407	0.820
Joint 8	0.146	0.476	0.461
Joint 9	0.150	NaN	NaN

Table 8.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.560	0.949	1.696

Table 8.3: Speed data

8.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_4/BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_4.mp4

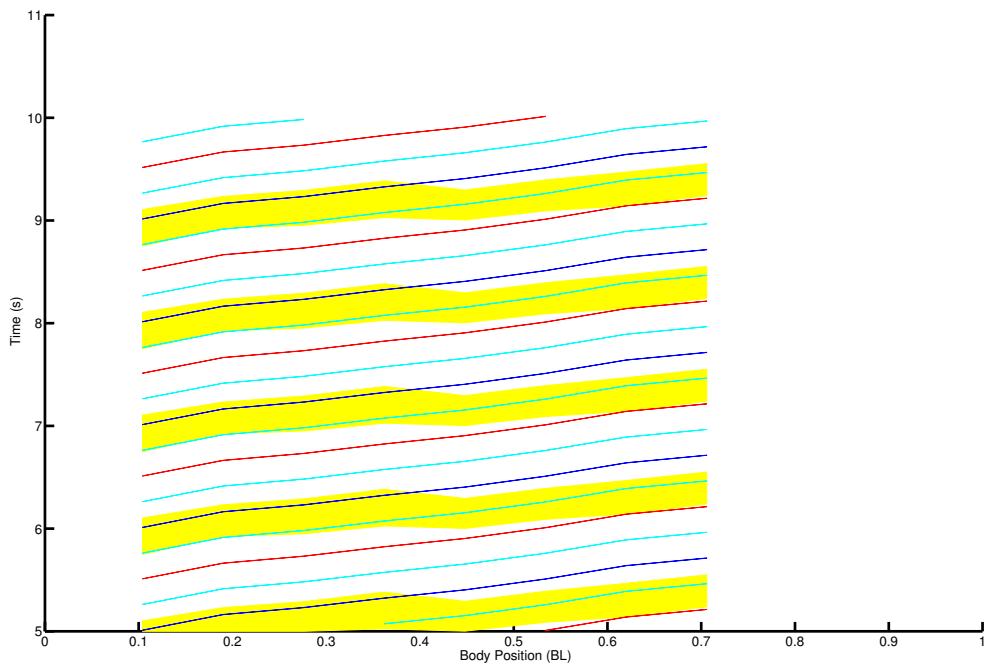


Figure 8.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_4

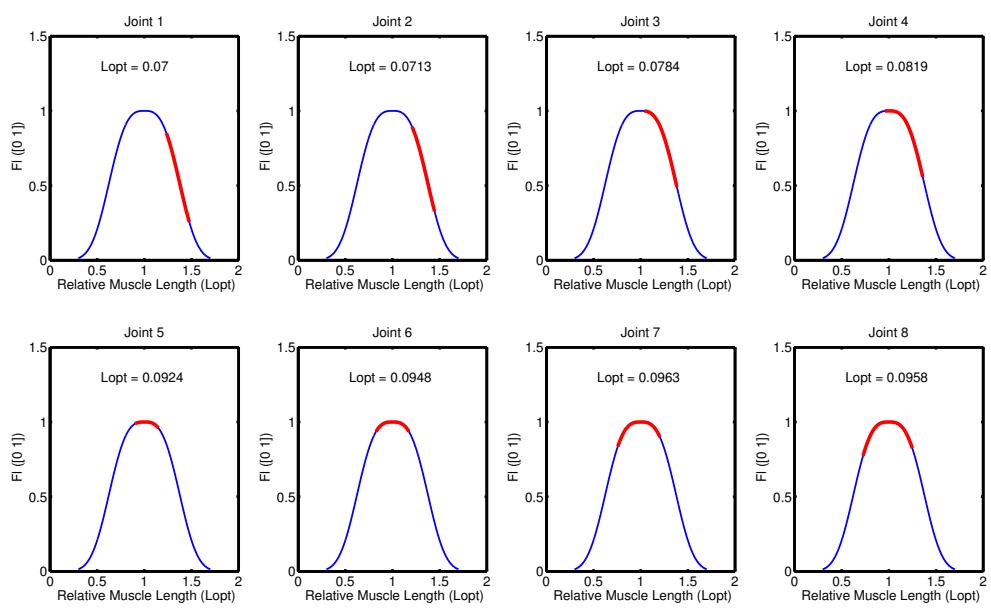


Figure 8.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_1Hz_4

8.3 Energy

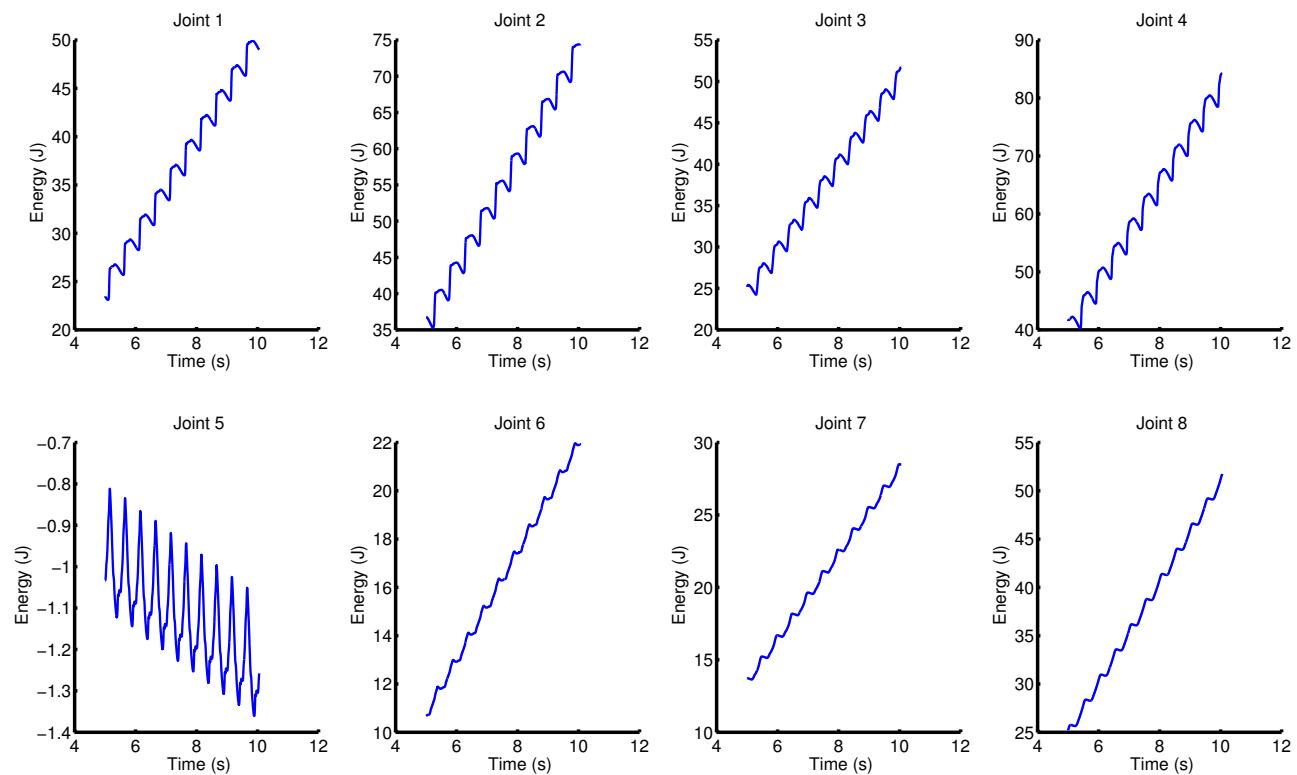


Figure 8.7: Energy_Opti_9seg_tail_w62_Full_1Hz_4

9 Opti_9seg_tail_w62_Full_1Hz_5

9.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_5/Opti_9seg_tail_w62_Full_1Hz_5.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	33.665	3.554	92.099	124.738	64.528	87.458	106.396	105.425
Lopt (m)	0.070	0.071	0.077	0.081	0.103	0.099	0.082	0.103
r (m)	0.137	0.137	0.124	0.115	0.139	0.137	0.040	0.119
TimeLag (s)	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748
error	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
Fitness	8.583	8.583	8.583	8.583	8.583	8.583	8.583	8.583

Table 9.1: Optimised Parameters

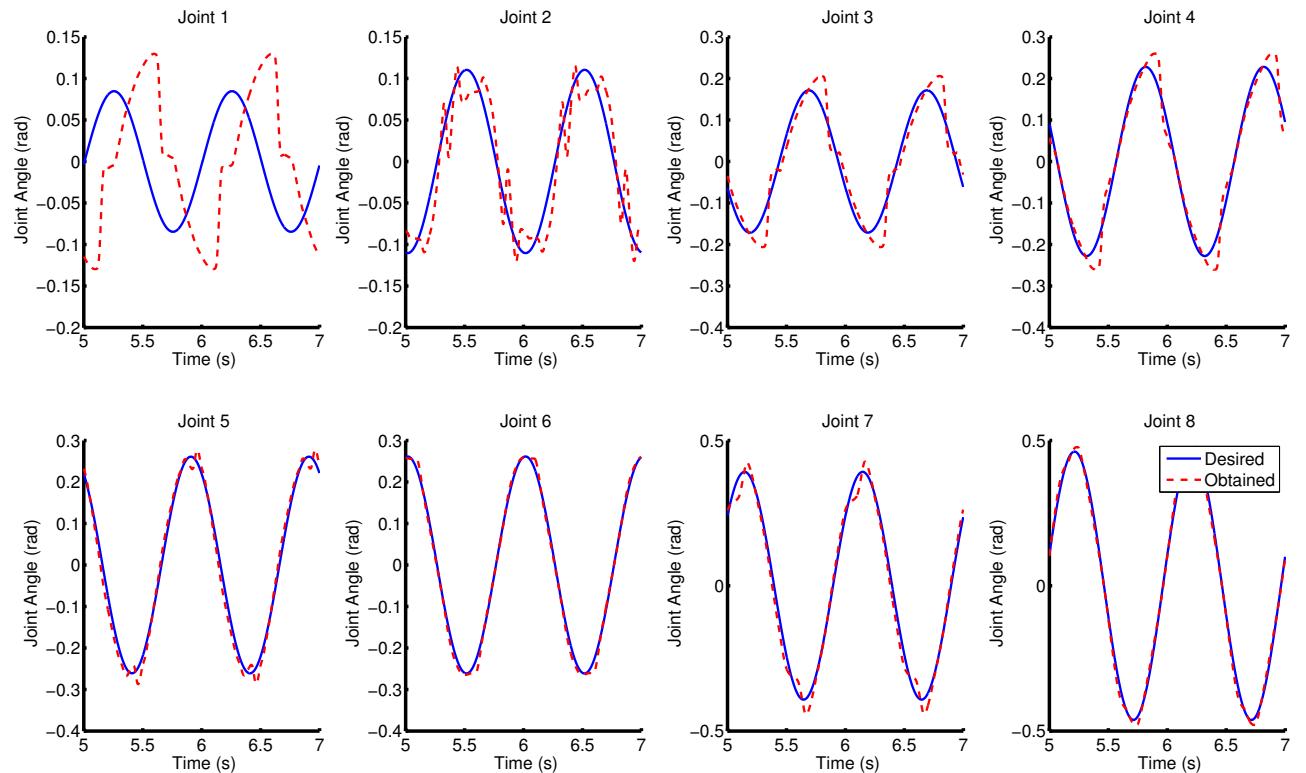


Figure 9.1: AngleDiff_Opti_9seg_tail_w62_Full_1Hz_5

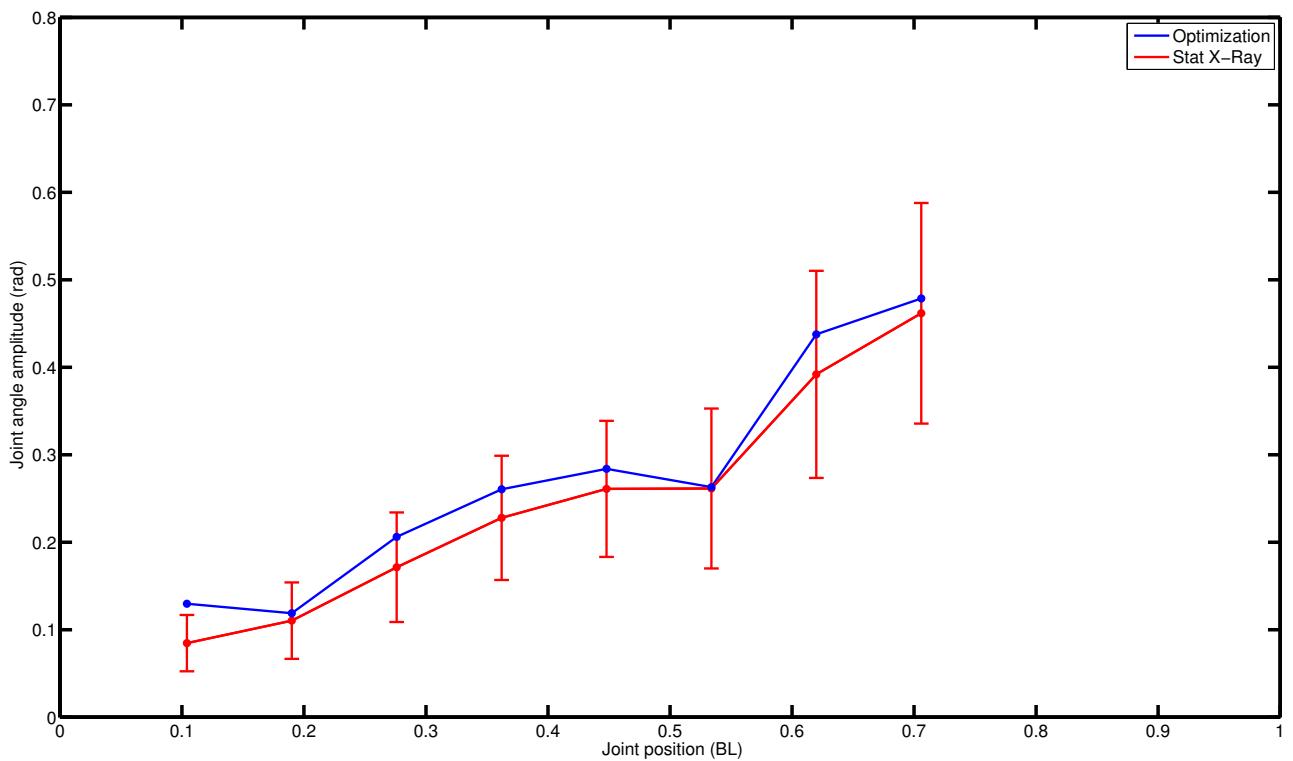


Figure 9.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_1Hz_5

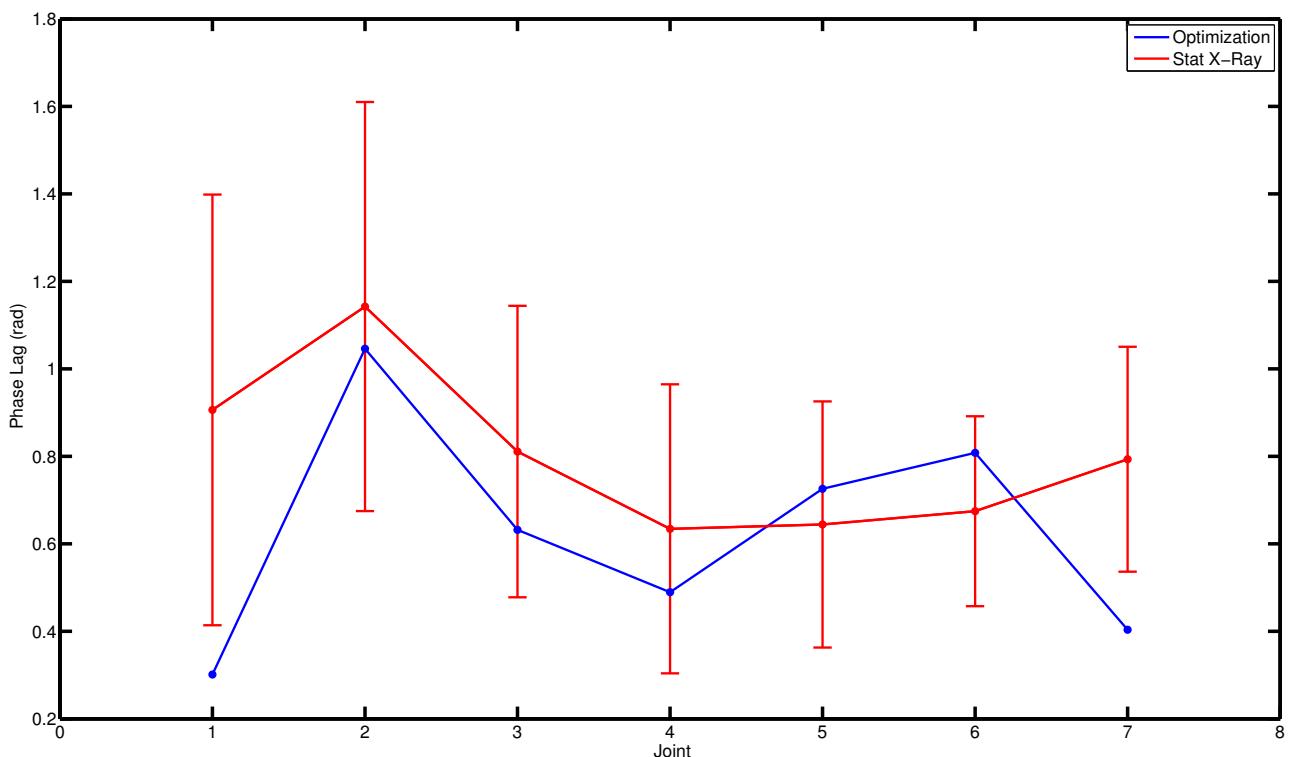


Figure 9.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_1Hz_5

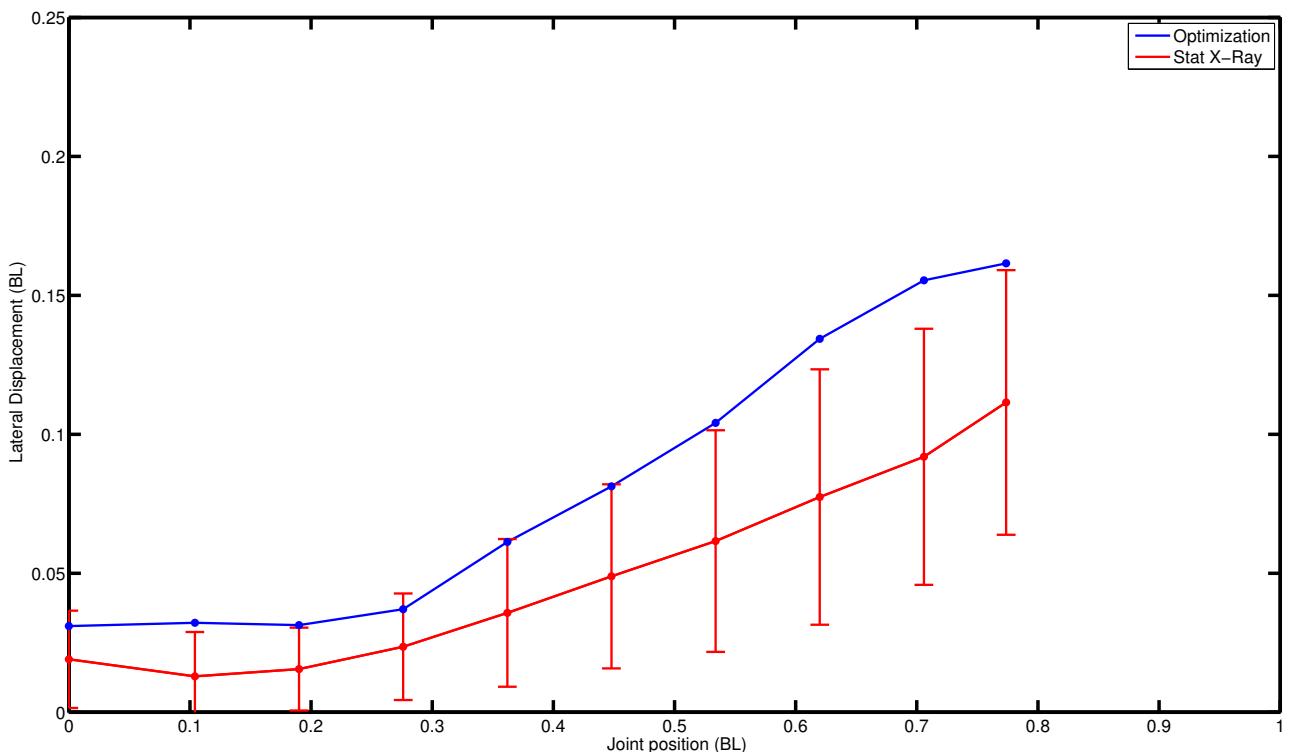


Figure 9.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_1Hz_5

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.031	NaN	NaN
Joint 1	0.032	0.130	NaN
Joint 2	0.031	0.119	0.301
Joint 3	0.037	0.206	1.046
Joint 4	0.061	0.261	0.632
Joint 5	0.081	0.284	0.489
Joint 6	0.104	0.263	0.726
Joint 7	0.134	0.438	0.808
Joint 8	0.155	0.479	0.404
Joint 9	0.162	NaN	NaN

Table 9.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.570	0.955	1.677

Table 9.3: Speed data

9.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_1Hz_5/BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_5.mp4

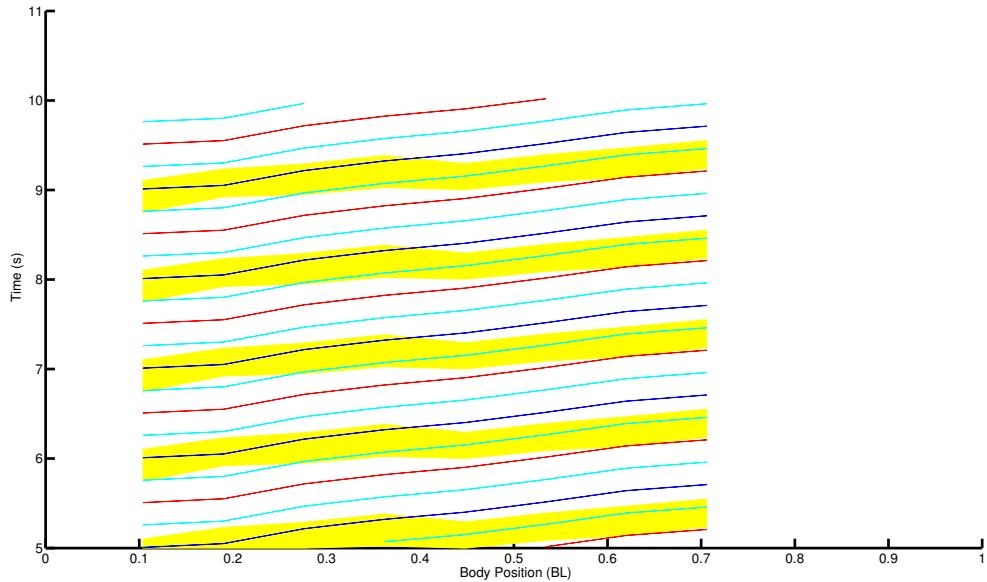


Figure 9.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_1Hz_5

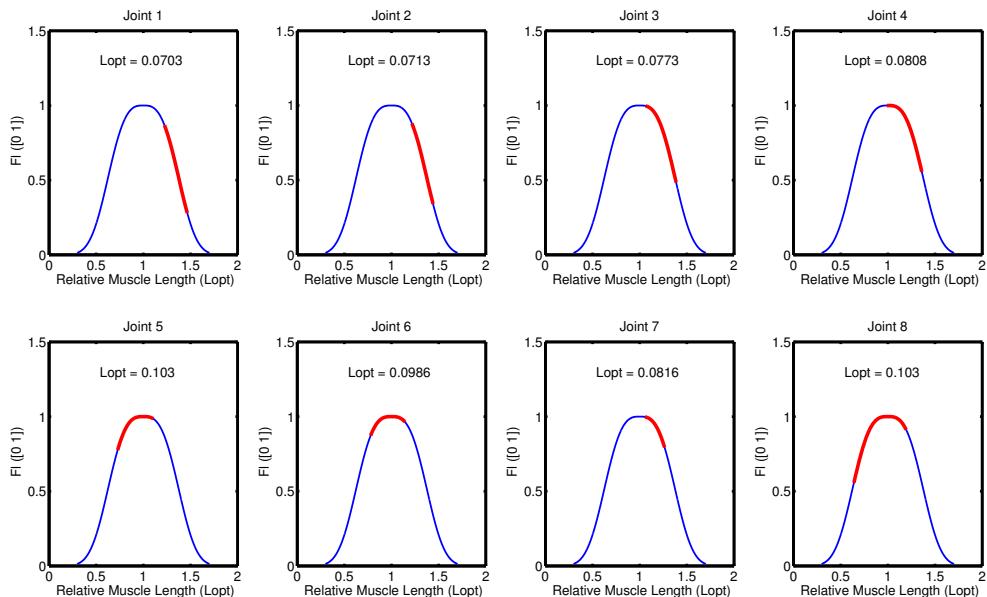


Figure 9.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_1Hz_5

9.3 Energy

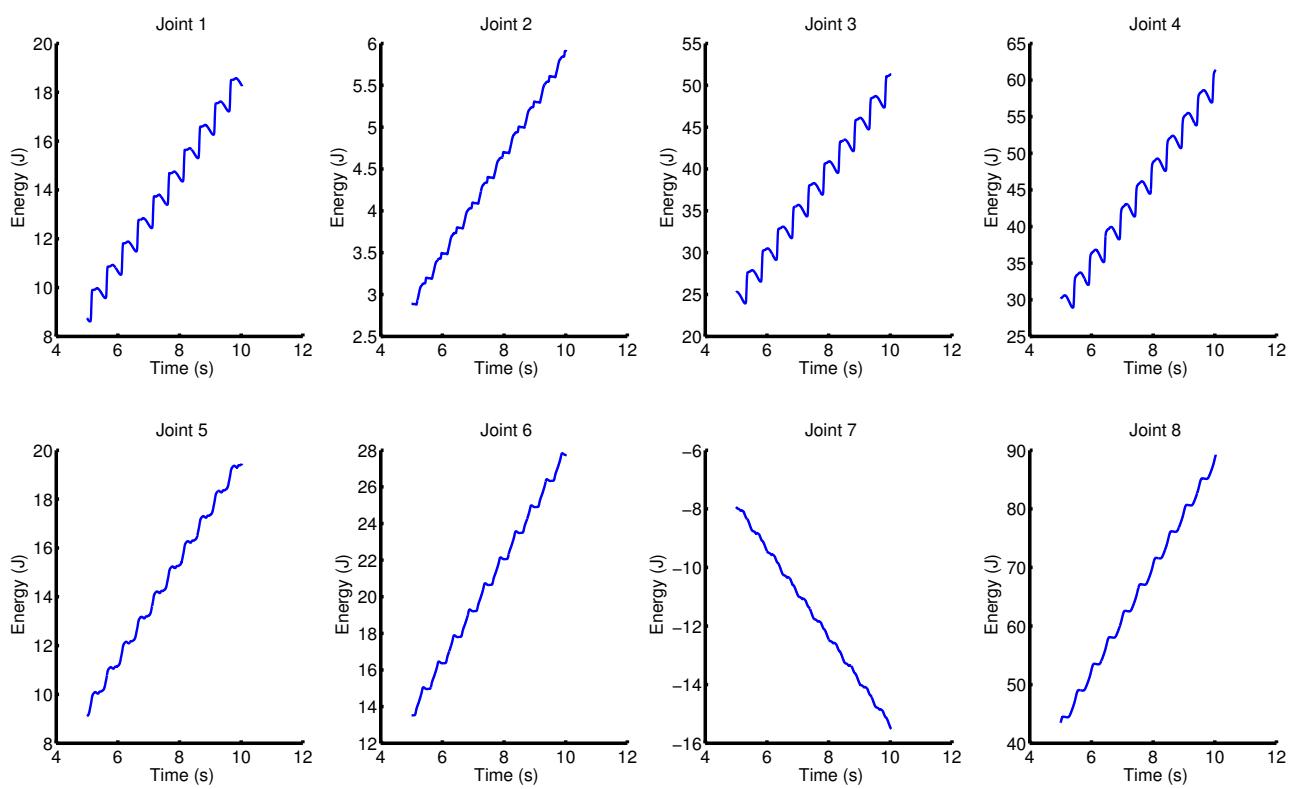


Figure 9.7: Energy_Opti_9seg_tail_w62_Full_1Hz_5

10 Opti_9seg_notail_w62_shaped_Full_1Hz_1

10.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_1/Opti_9seg_notail_w62_shaped_Full_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	10.717	176.908	108.840	95.782	80.392	20.629	105.898	180.625
Lopt (m)	0.075	0.070	0.071	0.075	0.085	0.080	0.109	0.115
r (m)	0.019	0.132	0.116	0.131	0.113	0.114	0.138	0.140
TimeLag (s)	0.654	0.654	0.654	0.654	0.654	0.654	0.654	0.654
error	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Fitness	4.120	4.120	4.120	4.120	4.120	4.120	4.120	4.120

Table 10.1: Optimised Parameters

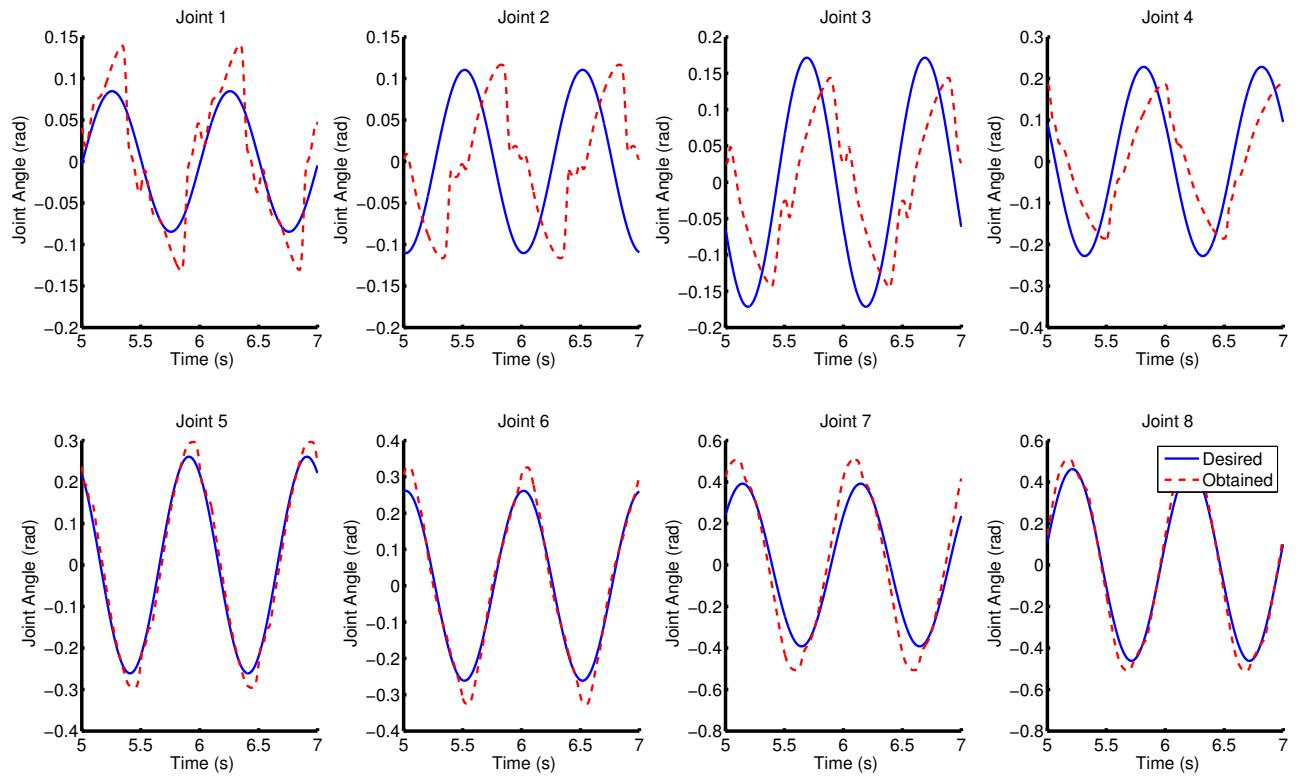


Figure 10.1: AngleDiff_Opti_9seg_notail_w62_shaped_Full_1Hz_1

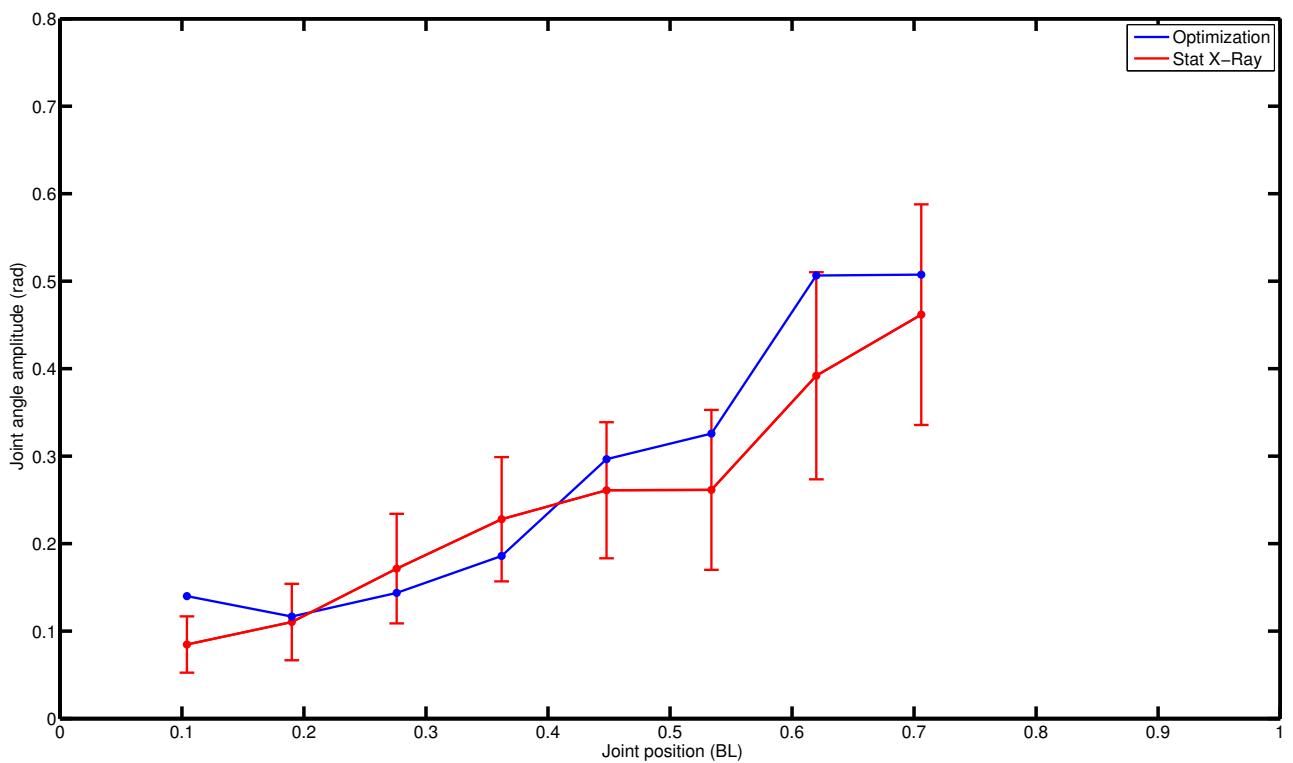


Figure 10.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Full_1Hz_1

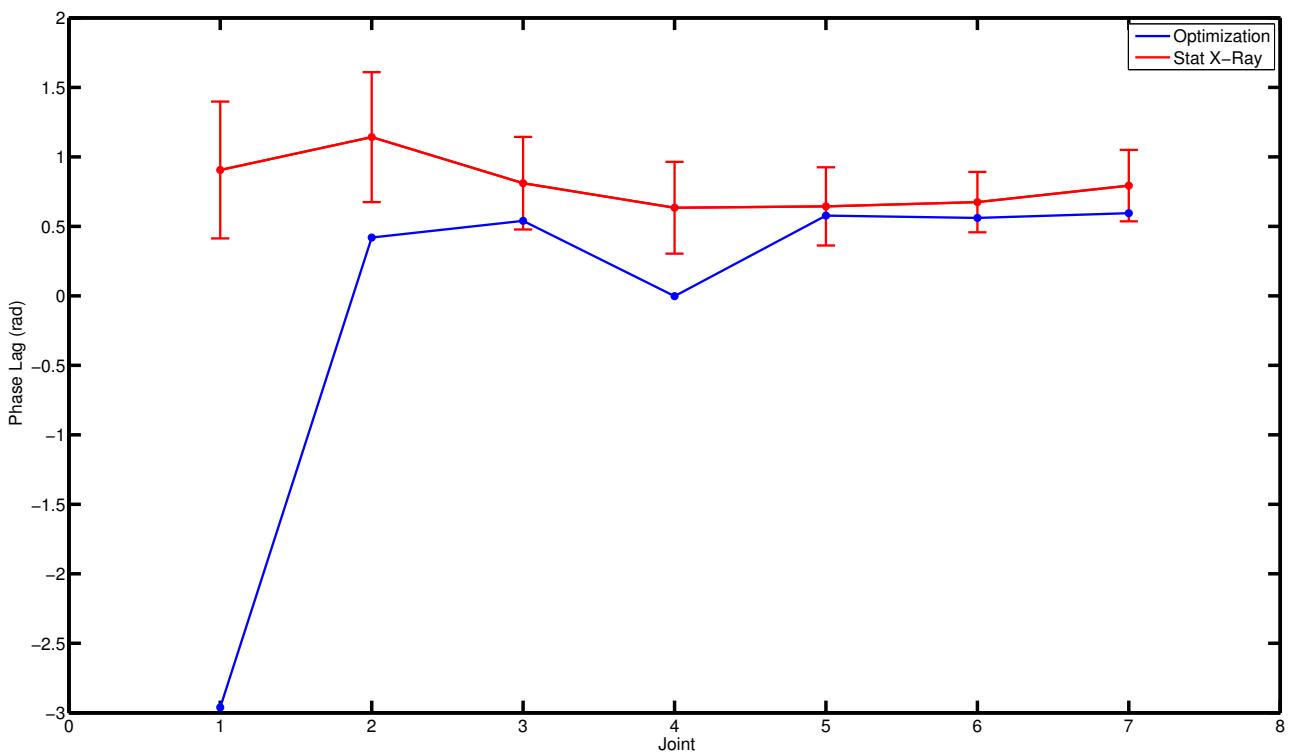


Figure 10.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Full_1Hz_1

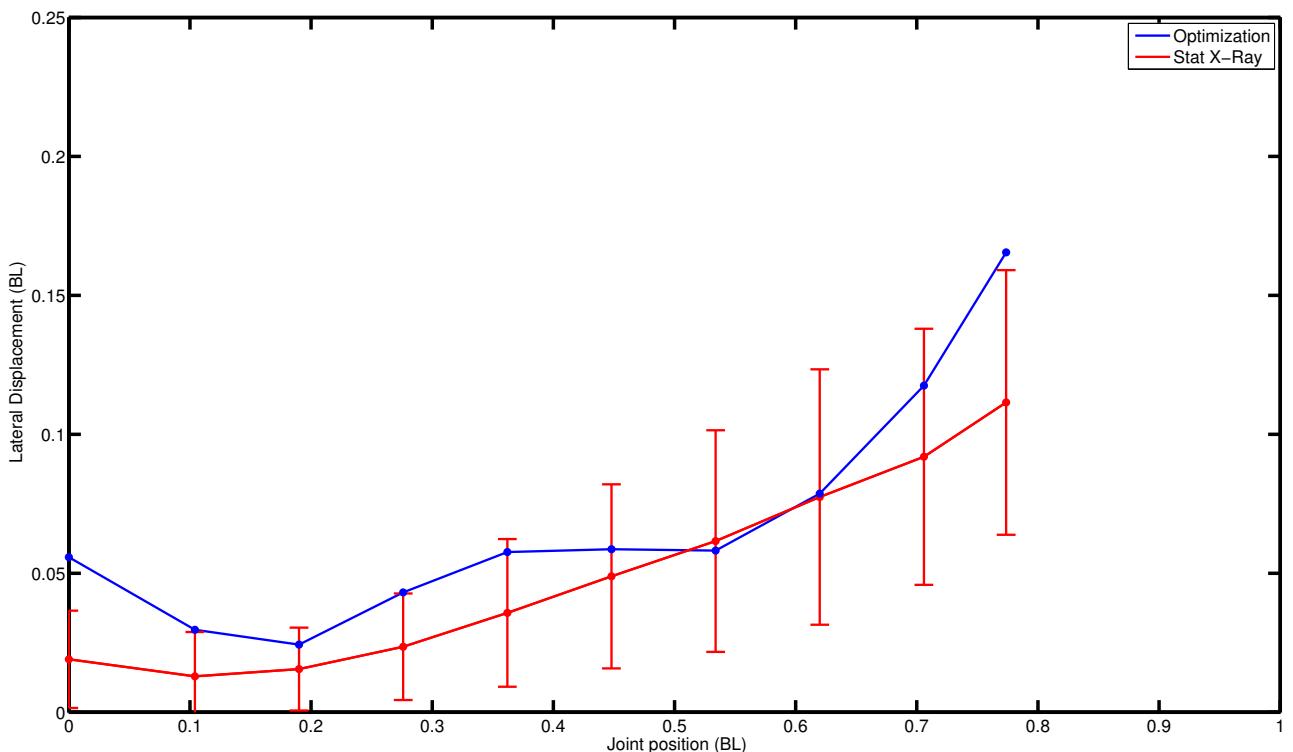


Figure 10.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Full_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.056	NaN	NaN
Joint 1	0.030	0.140	NaN
Joint 2	0.024	0.117	-2.962
Joint 3	0.043	0.144	0.420
Joint 4	0.058	0.186	0.540
Joint 5	0.059	0.296	-0.002
Joint 6	0.058	0.326	0.577
Joint 7	0.079	0.506	0.561
Joint 8	0.118	0.507	0.595
Joint 9	0.165	NaN	NaN

Table 10.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.255	0.776	3.036

Table 10.3: Speed data

10.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_1.mp4

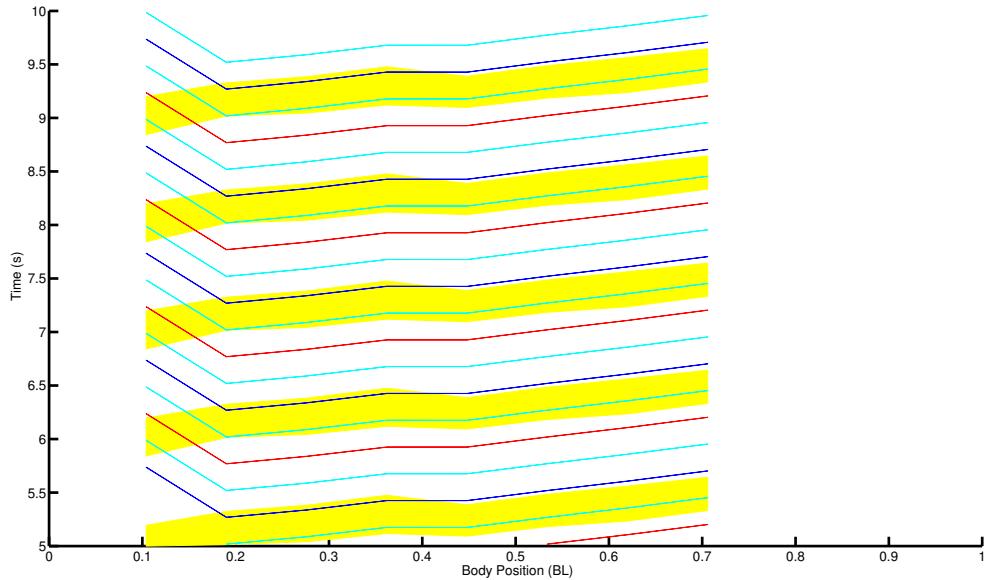


Figure 10.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_1

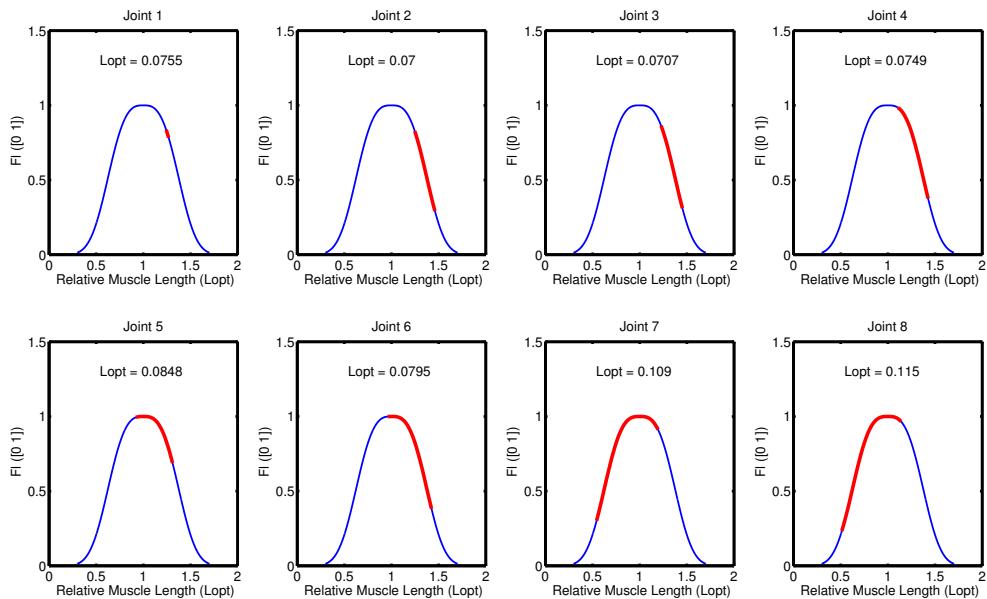


Figure 10.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Full_1Hz_1

10.3 Energy

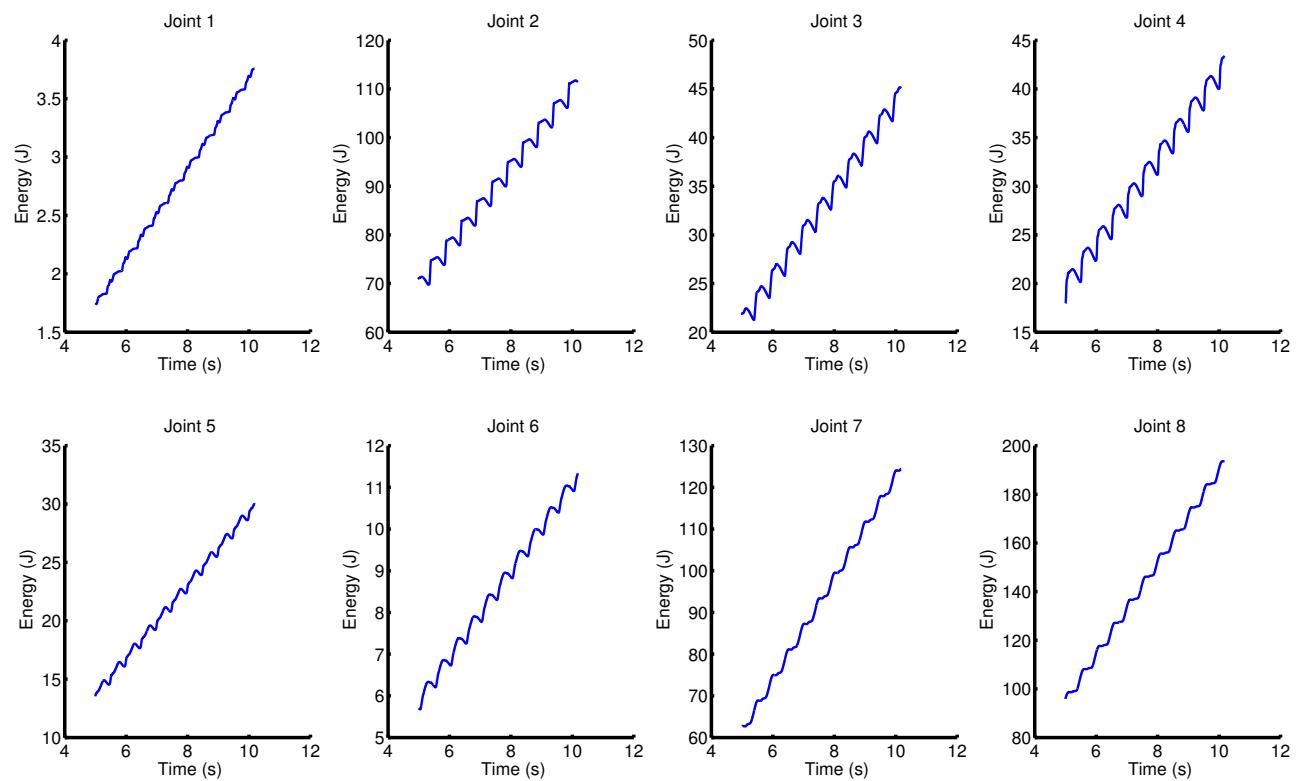


Figure 10.7: Energy_Opti_9seg_notail_w62_shaped_Full_1Hz_1

11 Opti_9seg_notail_w62_shaped_Full_1Hz_2

11.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_2/Opti_9seg_notail_w62_shaped_Full_1Hz_2.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	2.459	79.381	189.412	150.146	81.317	20.300	198.711	117.266
Lopt (m)	0.138	0.070	0.070	0.072	0.079	0.082	0.109	0.108
r (m)	0.110	0.139	0.122	0.110	0.083	0.137	0.140	0.140
TimeLag (s)	0.639	0.639	0.639	0.639	0.639	0.639	0.639	0.639
error	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241
Fitness	4.154	4.154	4.154	4.154	4.154	4.154	4.154	4.154

Table 11.1: Optimised Parameters

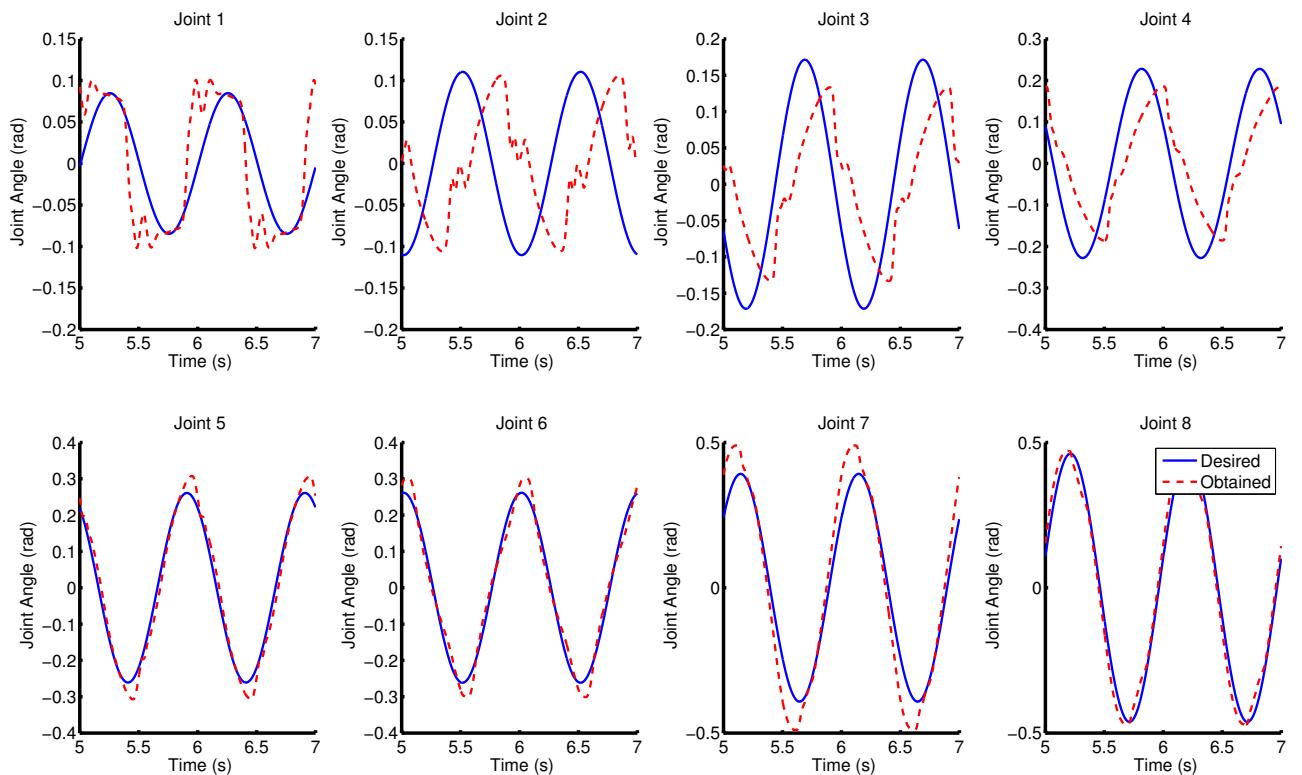


Figure 11.1: AngleDiff_Opti_9seg_notail_w62_shaped_Full_1Hz_2

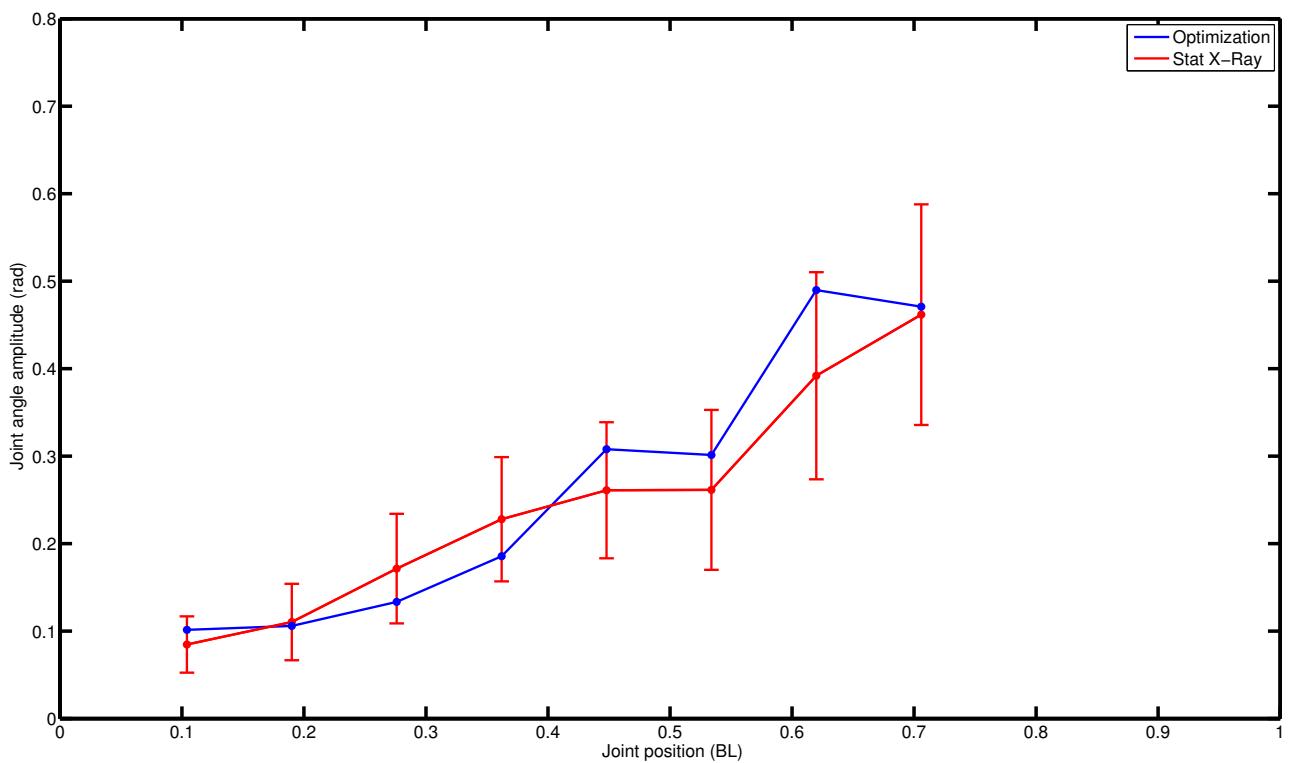


Figure 11.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Full_1Hz_2

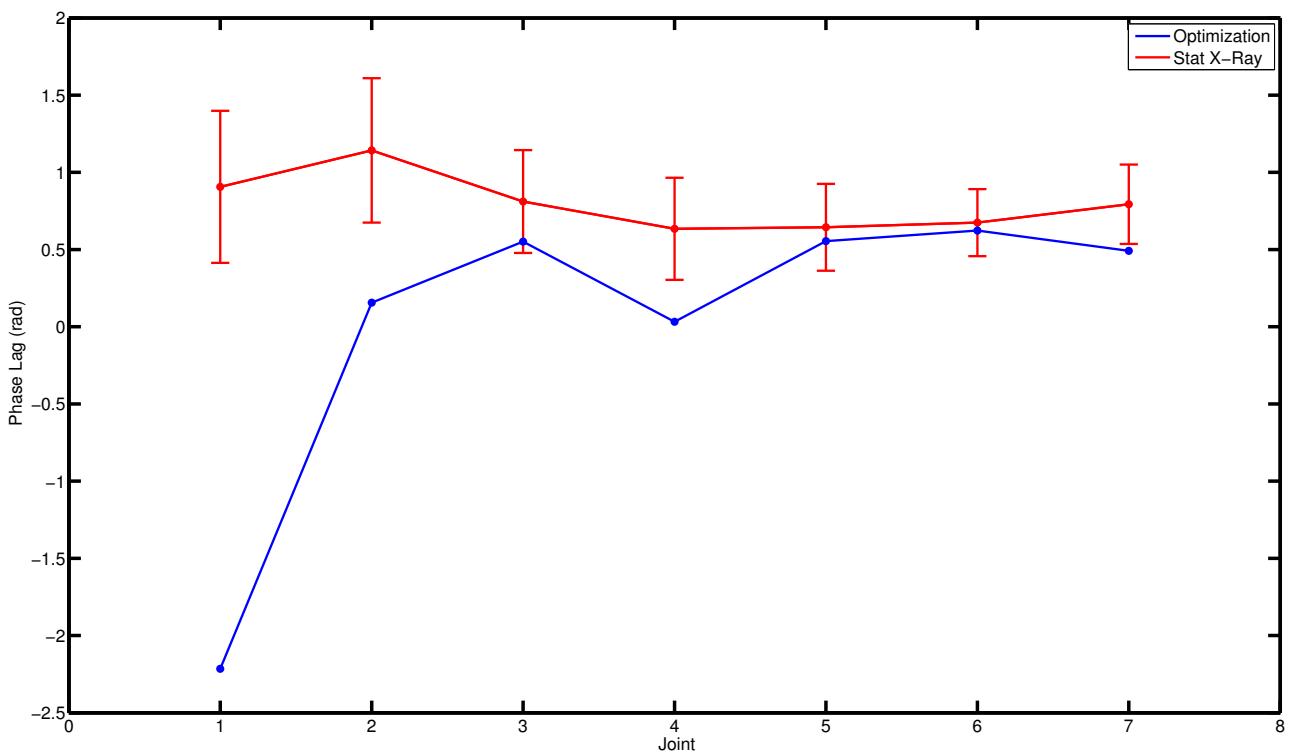


Figure 11.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Full_1Hz_2

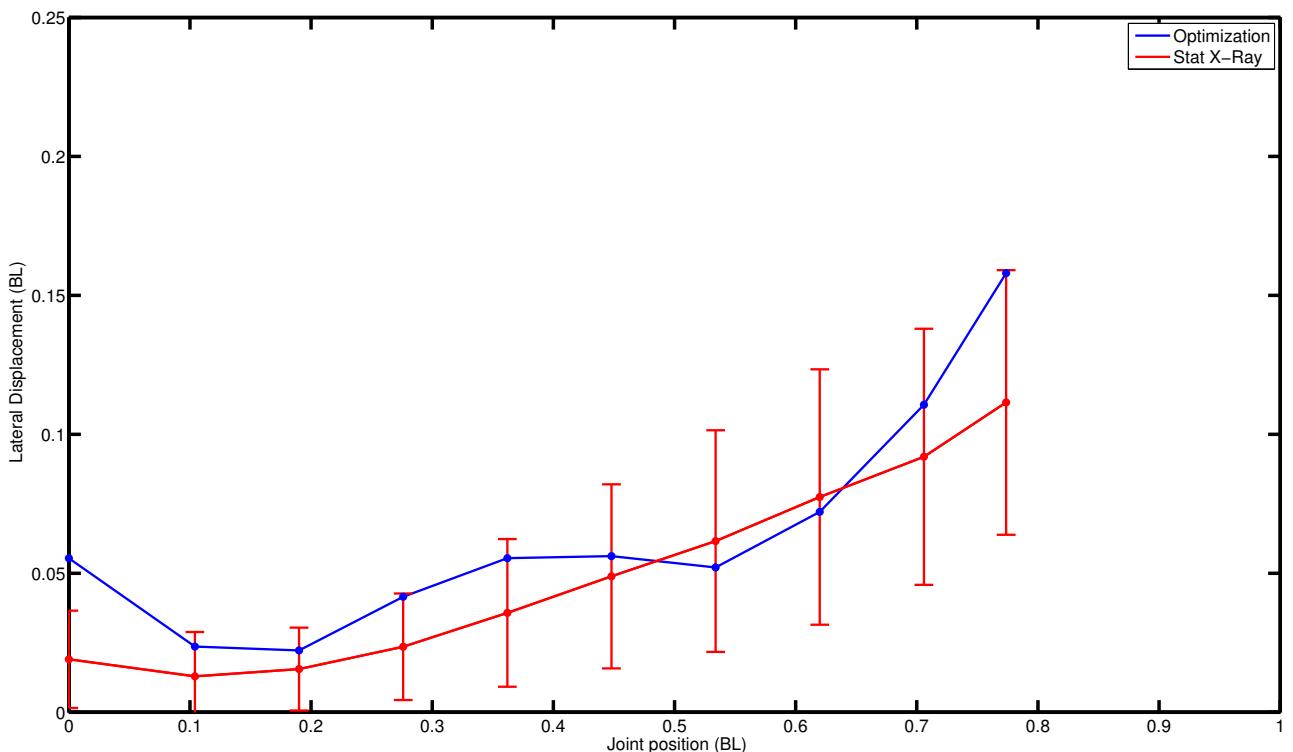


Figure 11.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Full_1Hz_2

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.055	NaN	NaN
Joint 1	0.024	0.101	NaN
Joint 2	0.022	0.106	-2.216
Joint 3	0.042	0.133	0.156
Joint 4	0.055	0.186	0.551
Joint 5	0.056	0.308	0.032
Joint 6	0.052	0.301	0.554
Joint 7	0.072	0.490	0.623
Joint 8	0.111	0.471	0.491
Joint 9	0.158	NaN	NaN

Table 11.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.250	0.640	2.557

Table 11.3: Speed data

11.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_2/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_2.mp4

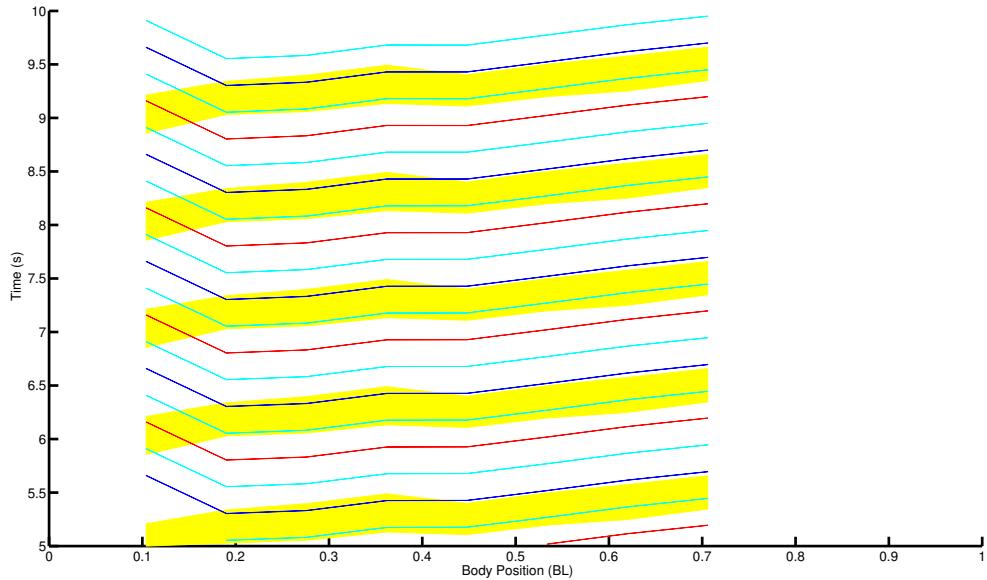


Figure 11.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_2

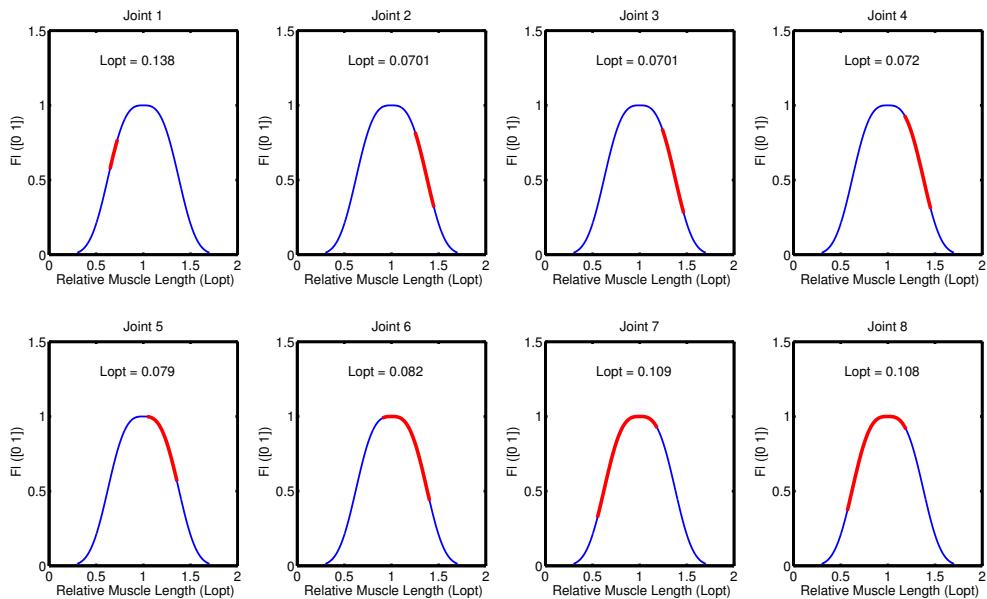


Figure 11.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Full_1Hz_2

11.3 Energy

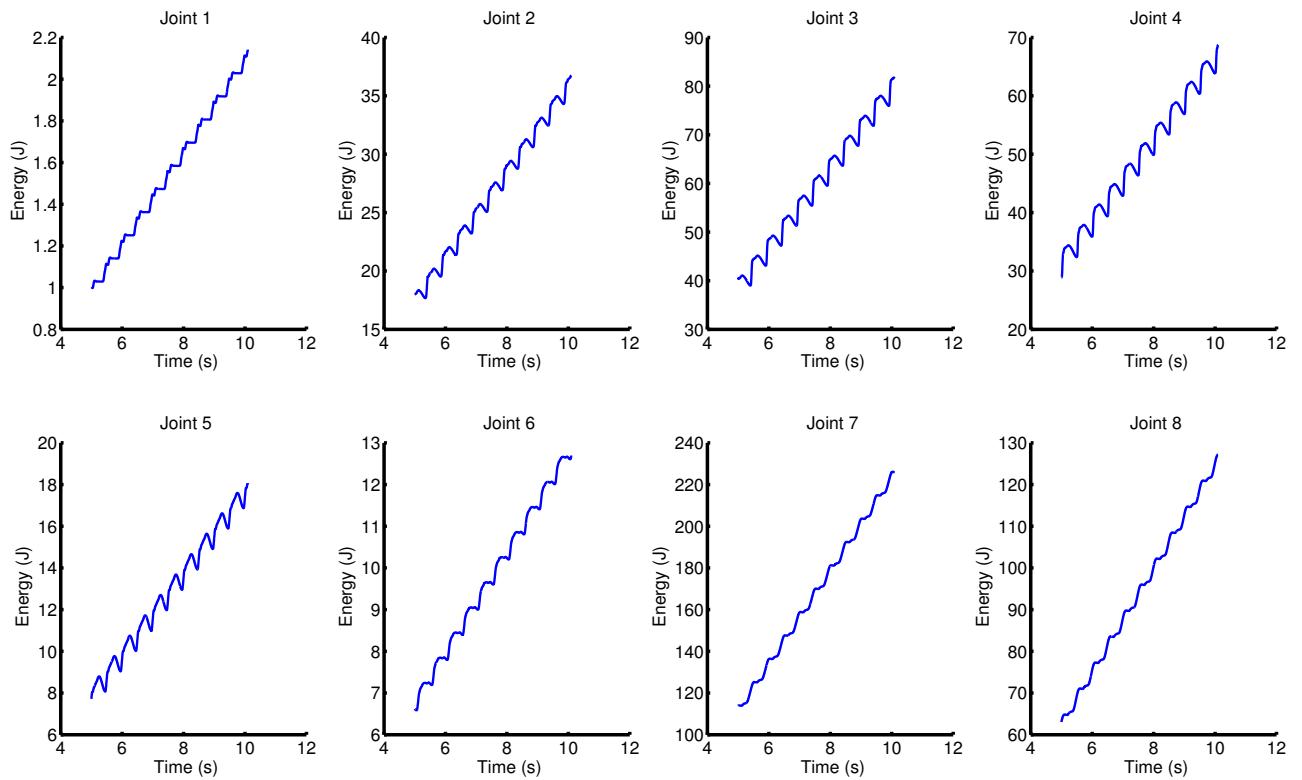


Figure 11.7: Energy_Opti_9seg_notail_w62_shaped_Full_1Hz_2

12 Opti_9seg_notail_w62_shaped_Full_1Hz_3

12.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_3/Opti_9seg_notail_w62_shaped_Full_1Hz_3.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	169.988	1.363	127.027	105.253	154.091	199.300	176.464	113.654
Lopt (m)	0.070	0.143	0.070	0.070	0.071	0.075	0.100	0.098
r (m)	0.139	0.074	0.139	0.138	0.076	0.079	0.139	0.125
TimeLag (s)	0.589	0.589	0.589	0.589	0.589	0.589	0.589	0.589
error	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322
Fitness	3.102	3.102	3.102	3.102	3.102	3.102	3.102	3.102

Table 12.1: Optimised Parameters

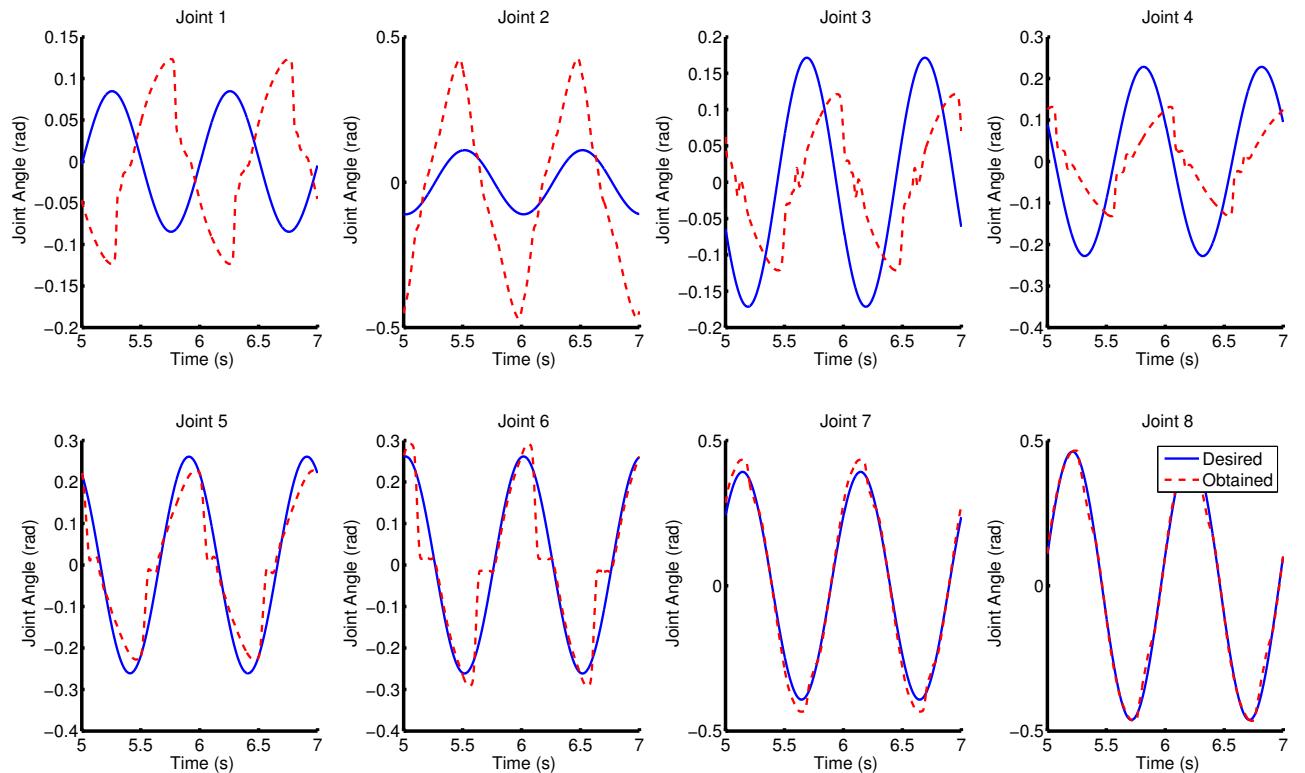


Figure 12.1: AngleDiff_Opti_9seg_notail_w62_shaped_Full_1Hz_3

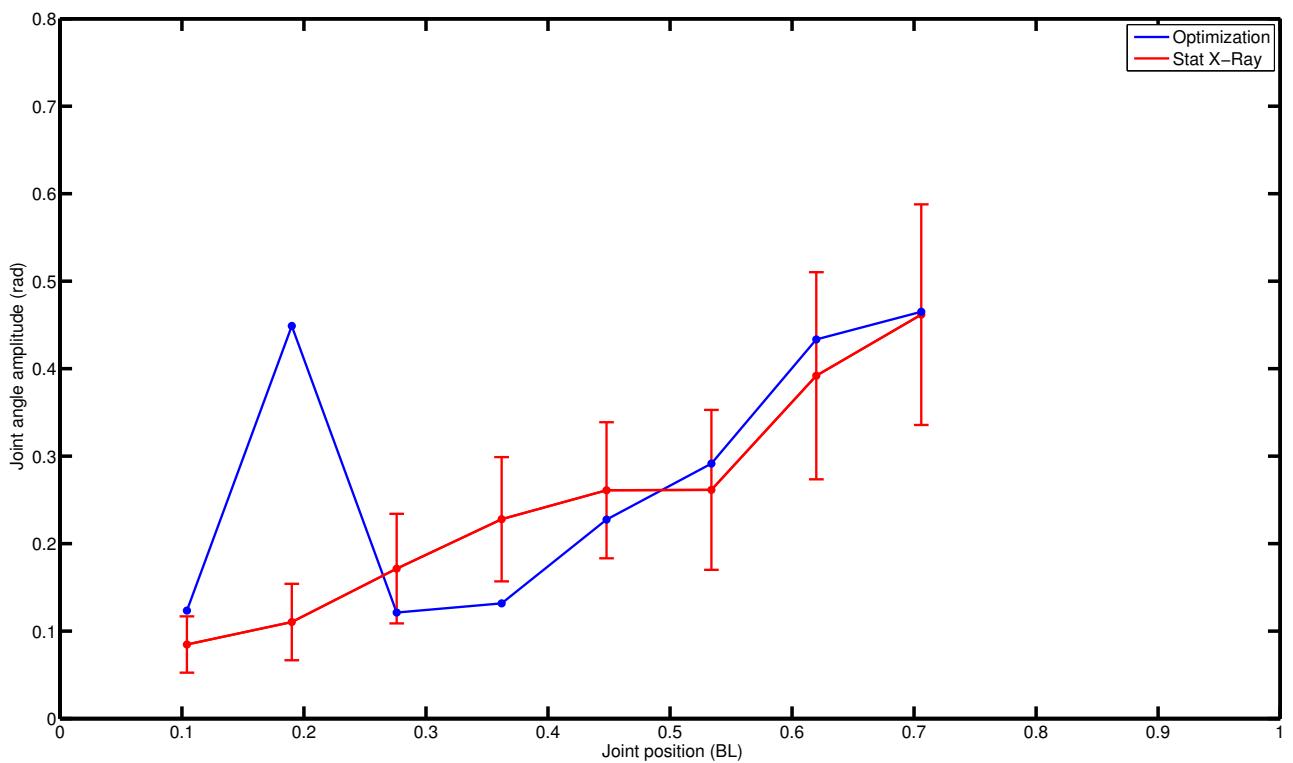


Figure 12.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Full_1Hz_3

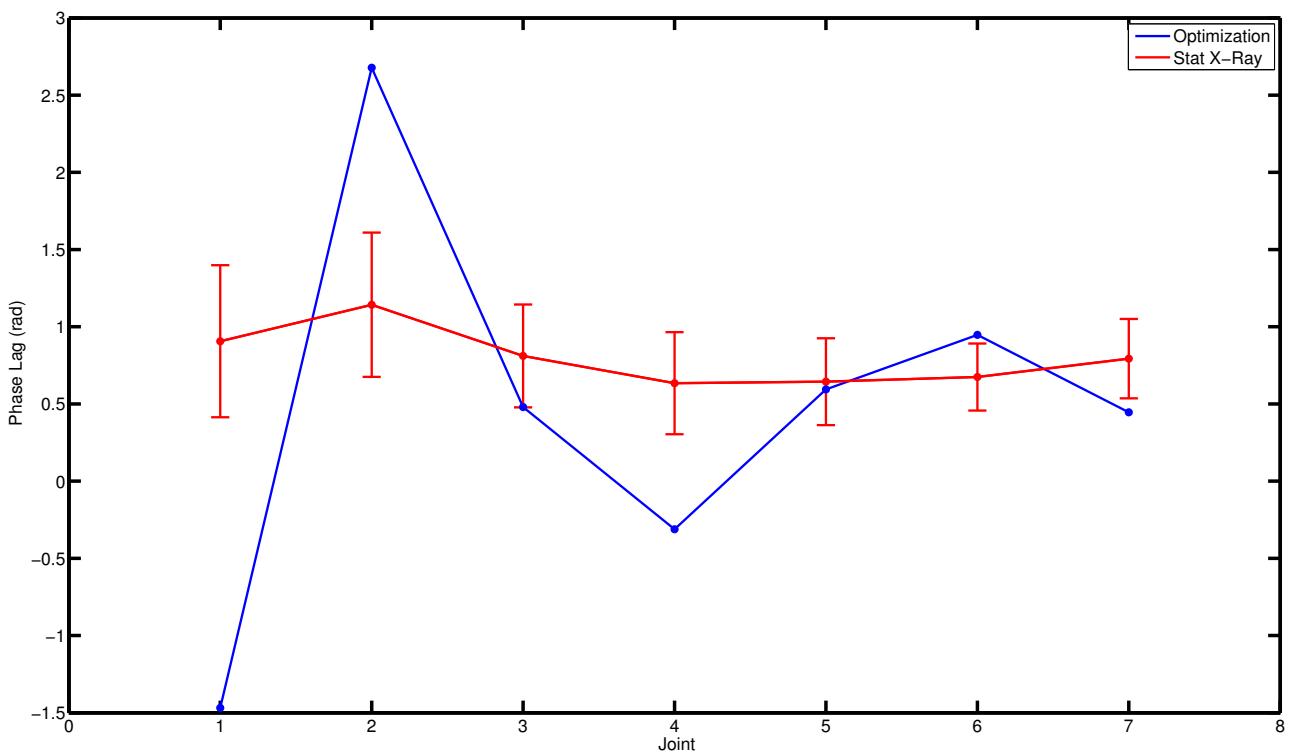


Figure 12.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Full_1Hz_3

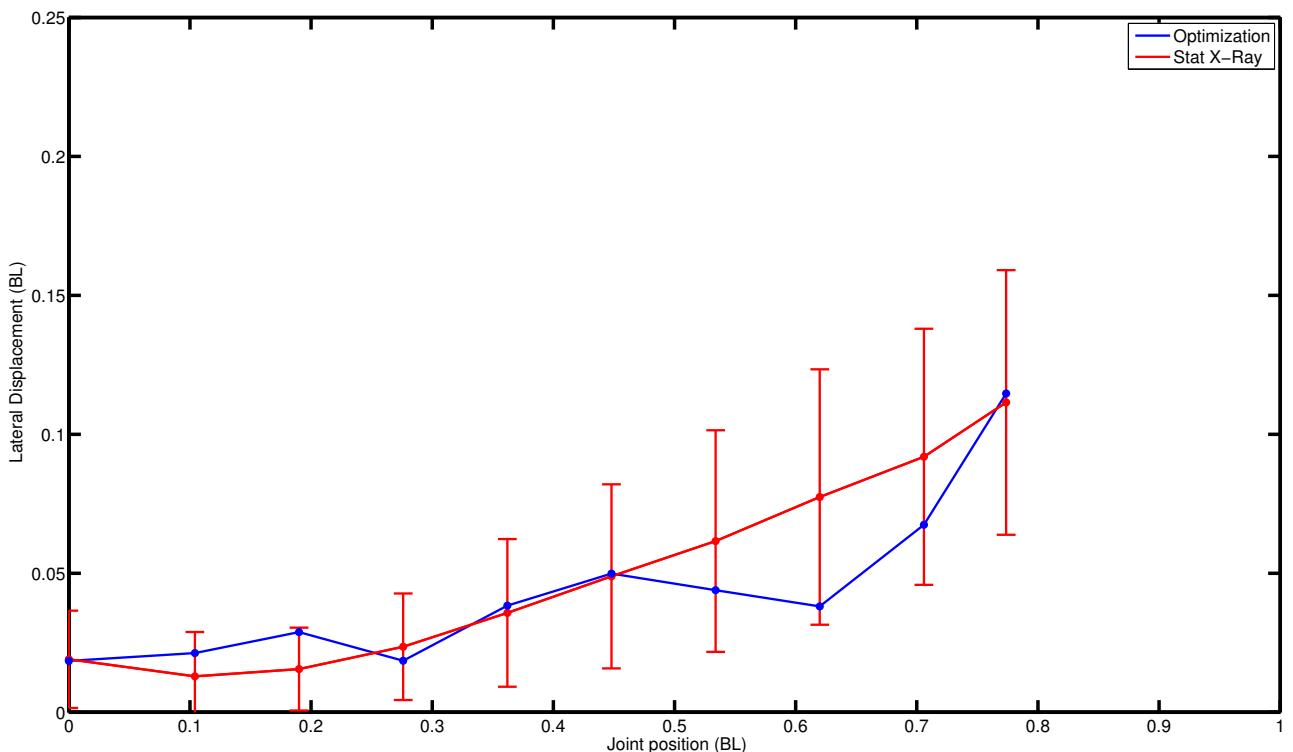


Figure 12.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Full_1Hz_3

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.018	NaN	NaN
Joint 1	0.021	0.123	NaN
Joint 2	0.029	0.449	-1.469
Joint 3	0.019	0.121	2.678
Joint 4	0.038	0.132	0.480
Joint 5	0.050	0.228	-0.312
Joint 6	0.044	0.292	0.594
Joint 7	0.038	0.433	0.947
Joint 8	0.067	0.465	0.446
Joint 9	0.115	NaN	NaN

Table 12.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.152	0.139	0.916

Table 12.3: Speed data

12.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_3/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_3.mp4

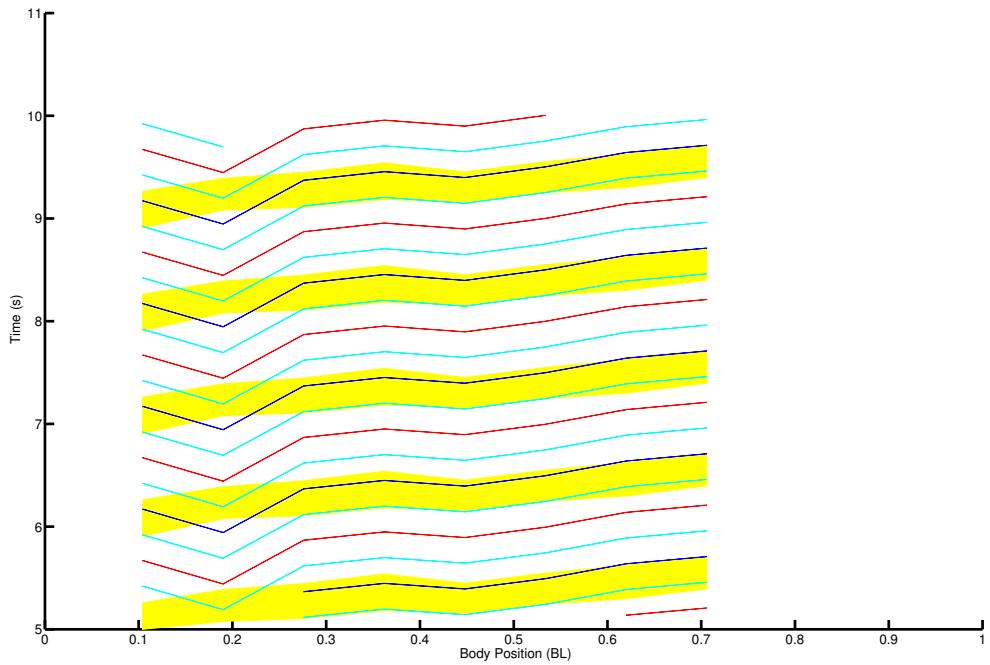


Figure 12.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_3

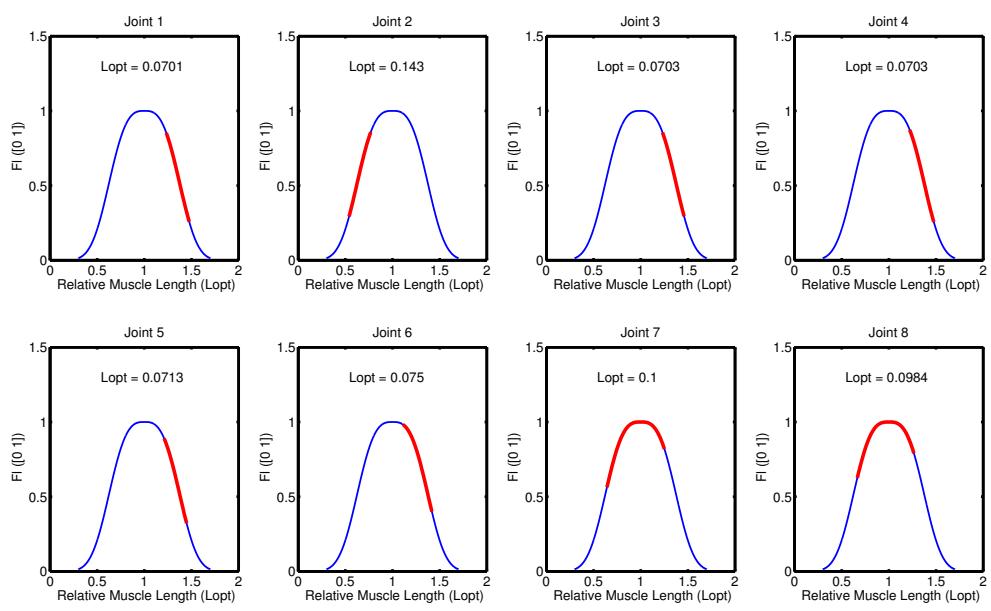


Figure 12.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Full_1Hz_3

12.3 Energy

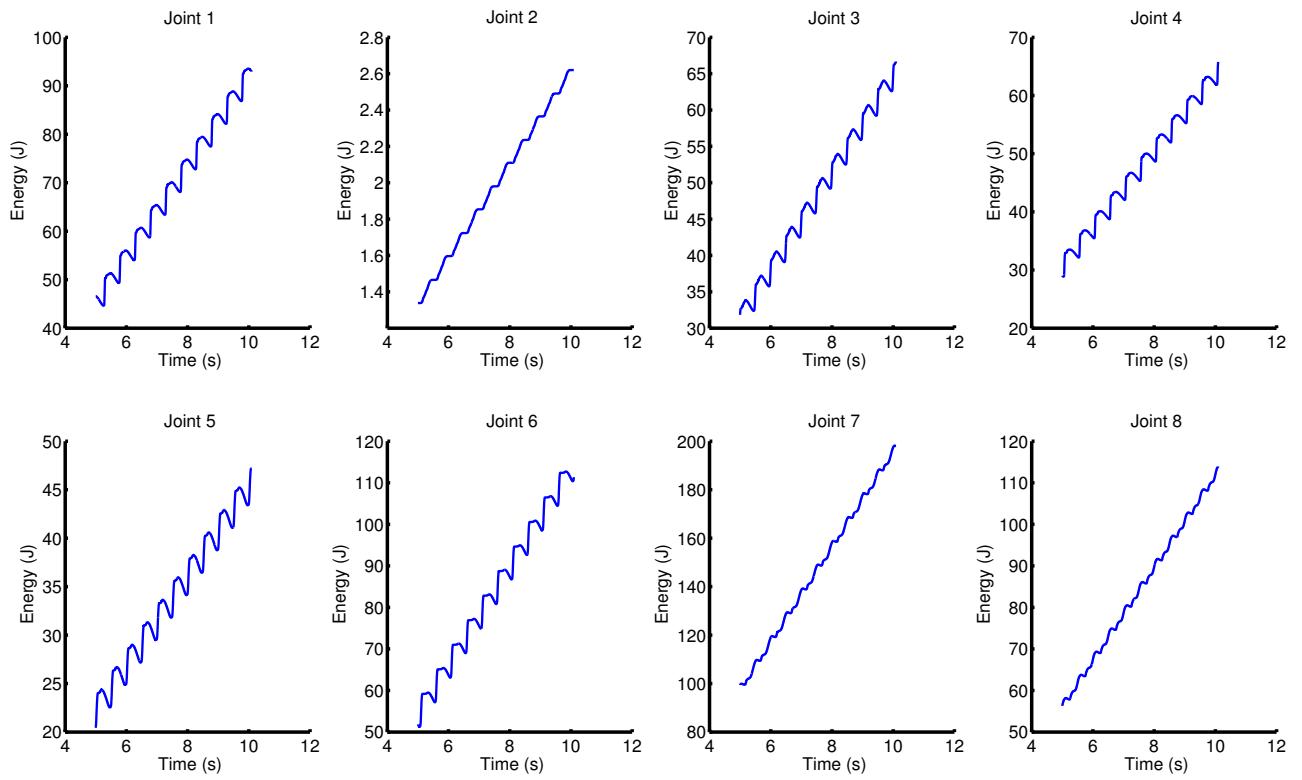


Figure 12.7: Energy_Opti_9seg_notail_w62_shaped_Full_1Hz_3

13 Opti_9seg_notail_w62_shaped_Full_1Hz_4

13.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_4/Opti_9seg_notail_w62_shaped_Full_1Hz_4.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	94.076	3.333	30.833	75.049	47.535	38.133	17.632	90.403
Lopt (m)	0.070	0.106	0.070	0.071	0.096	0.078	0.098	0.117
r (m)	0.136	0.092	0.126	0.129	0.132	0.072	0.139	0.138
TimeLag (s)	0.684	0.684	0.684	0.684	0.684	0.684	0.684	0.684
error	0.307	0.307	0.307	0.307	0.307	0.307	0.307	0.307
Fitness	3.259	3.259	3.259	3.259	3.259	3.259	3.259	3.259

Table 13.1: Optimised Parameters

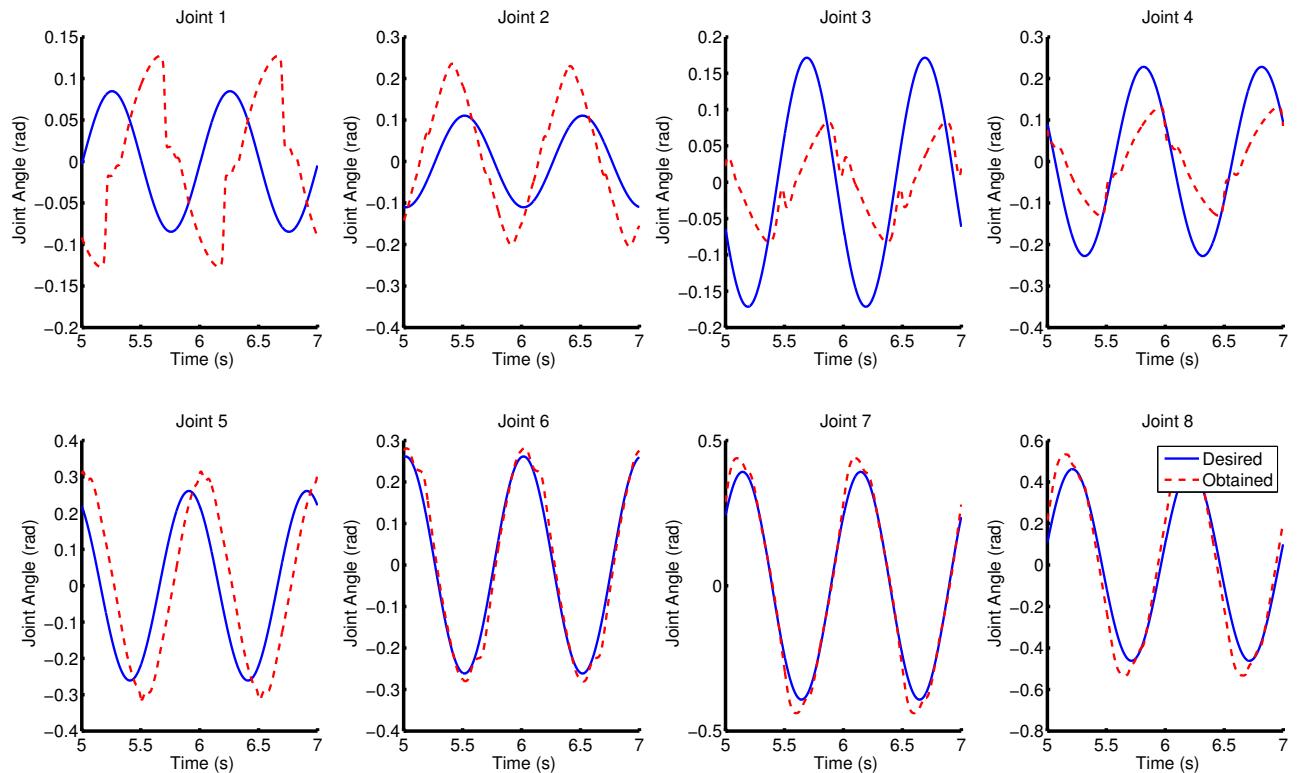


Figure 13.1: AngleDiff_Opti_9seg_notail_w62_shaped_Full_1Hz_4

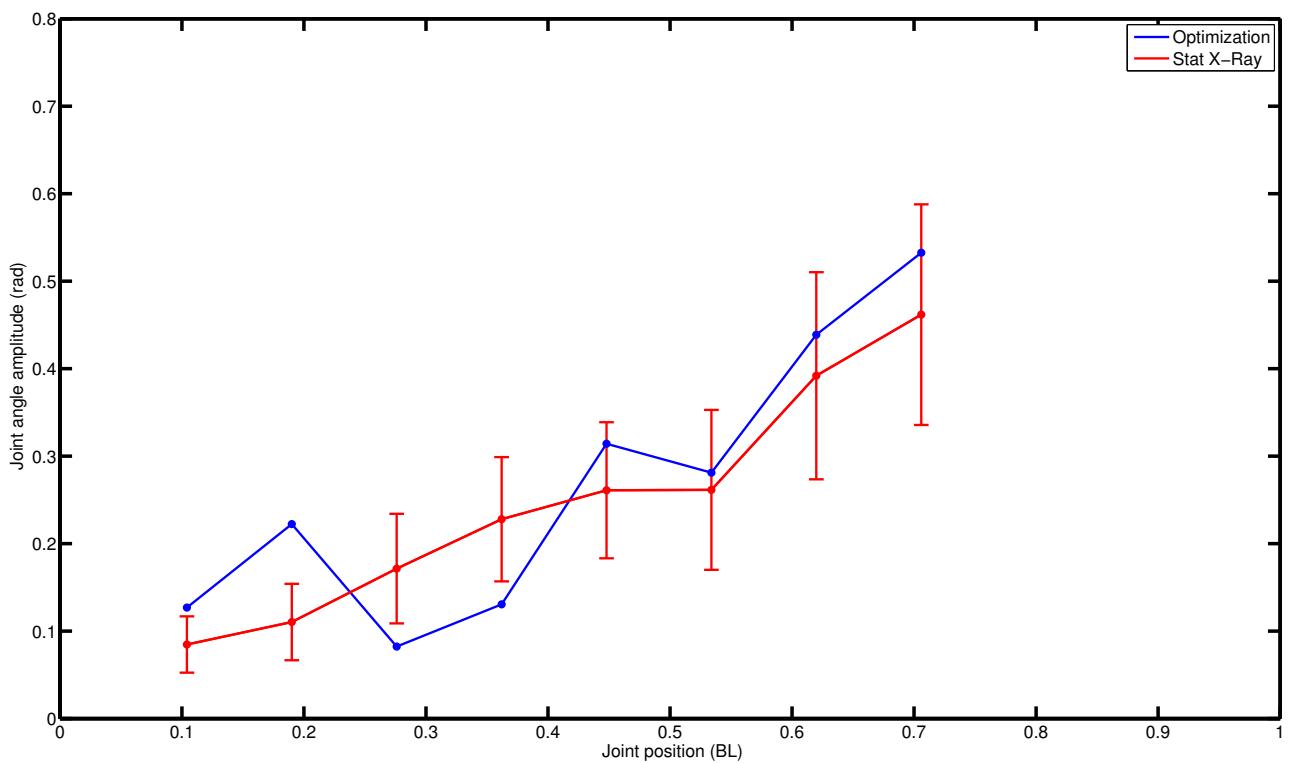


Figure 13.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Full_1Hz_4

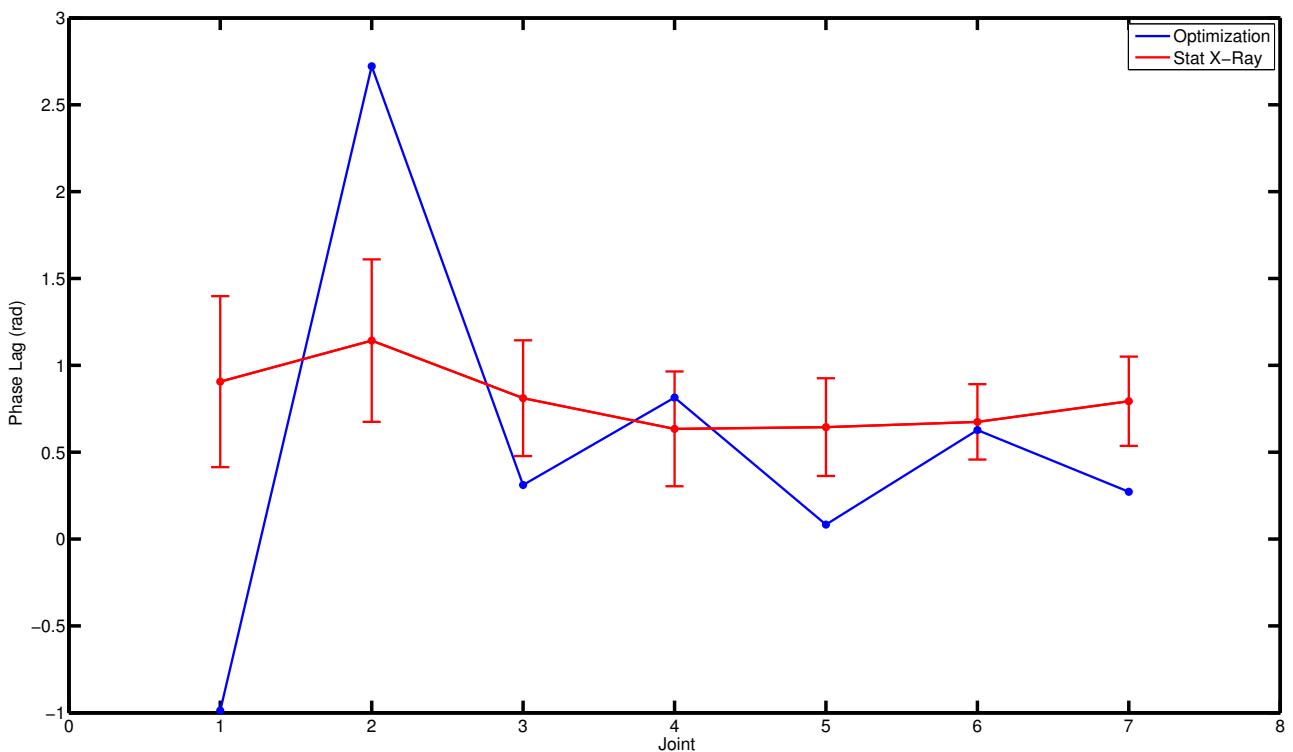


Figure 13.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Full_1Hz_4

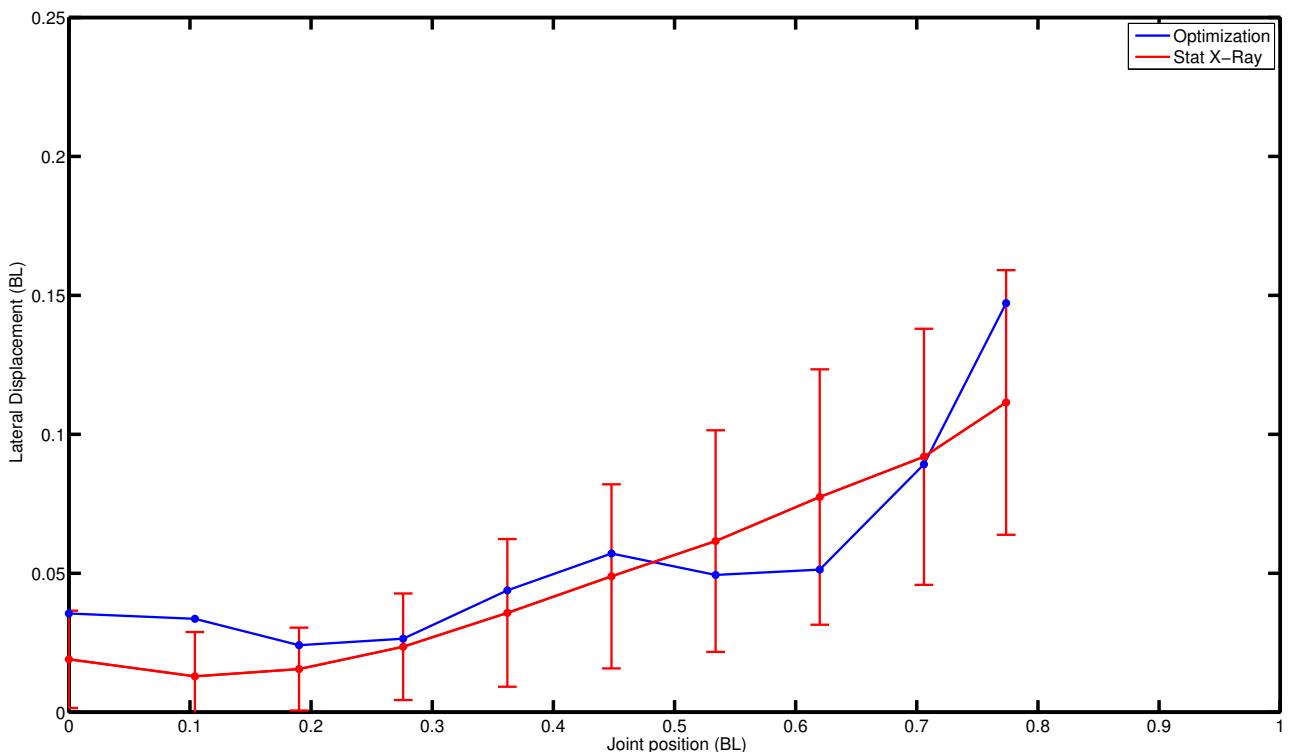


Figure 13.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Full_1Hz_4

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.036	NaN	NaN
Joint 1	0.034	0.127	NaN
Joint 2	0.024	0.222	-0.988
Joint 3	0.026	0.082	2.722
Joint 4	0.044	0.131	0.311
Joint 5	0.057	0.314	0.814
Joint 6	0.049	0.281	0.083
Joint 7	0.051	0.439	0.627
Joint 8	0.089	0.533	0.272
Joint 9	0.147	NaN	NaN

Table 13.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.177	0.321	1.809

Table 13.3: Speed data

13.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_4/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_4.mp4

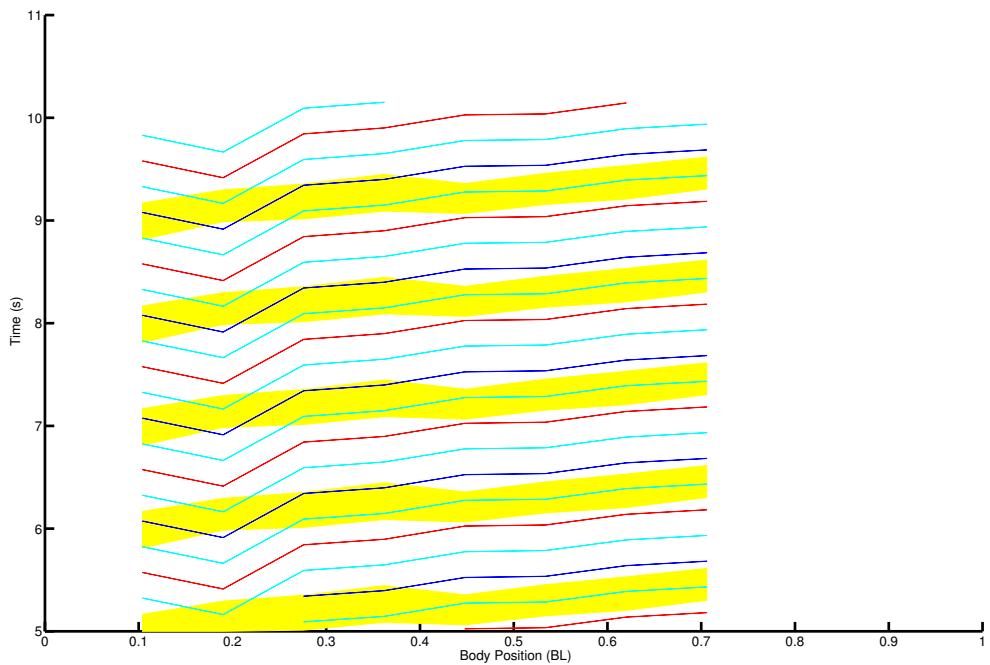


Figure 13.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_4

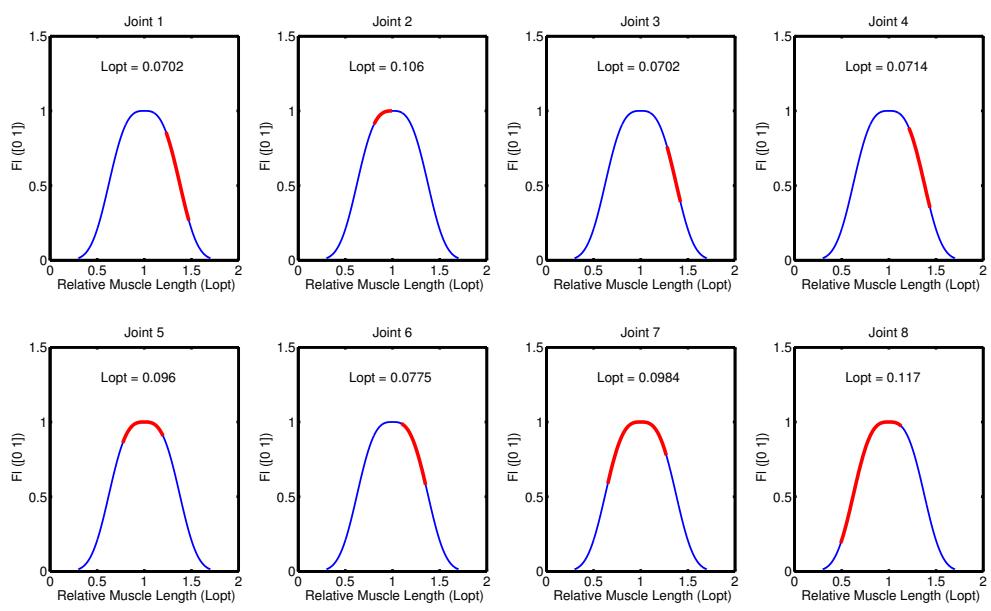


Figure 13.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Full_1Hz_4

13.3 Energy

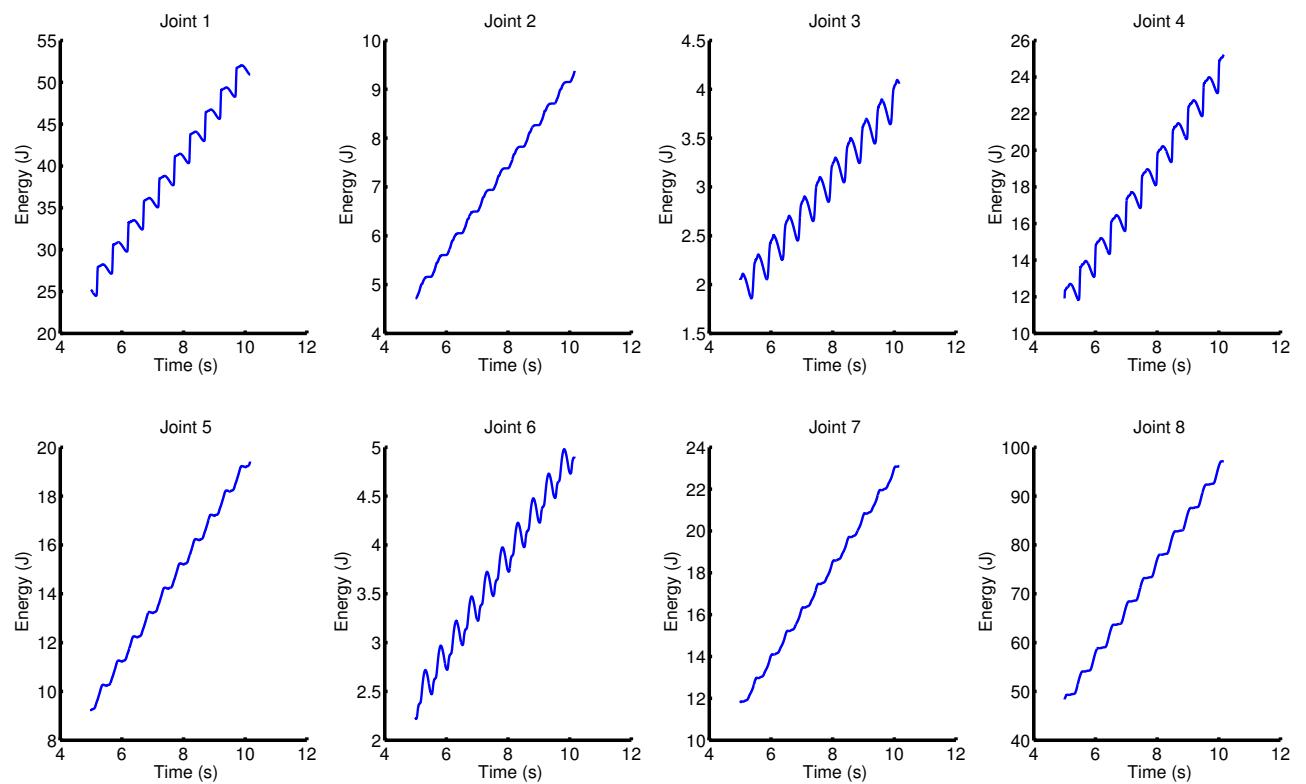


Figure 13.7: Energy_Opti_9seg_notail_w62_shaped_Full_1Hz_4

14 Opti_9seg_notail_w62_shaped_Full_1Hz_5

14.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_5/Opti_9seg_notail_w62_shaped_Full_1Hz_5.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	87.180	131.368	150.796	90.089	95.426	40.254	189.329	178.099
Lopt (m)	0.110	0.138	0.093	0.076	0.103	0.104	0.071	0.101
r (m)	0.133	0.123	0.130	0.025	0.087	0.139	0.112	0.107
TimeLag (s)	0.586	0.586	0.586	0.586	0.586	0.586	0.586	0.586
error	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
Fitness	1.594	1.594	1.594	1.594	1.594	1.594	1.594	1.594

Table 14.1: Optimised Parameters

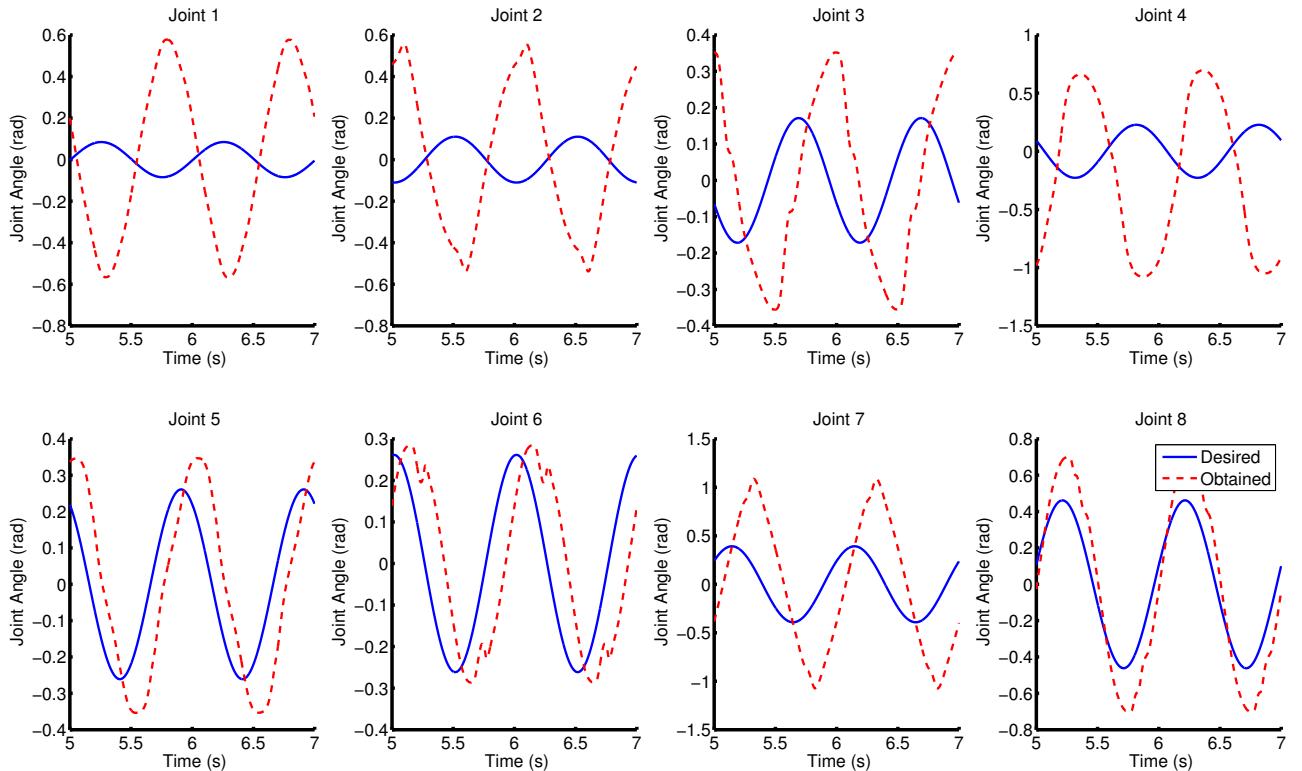


Figure 14.1: AngleDiff_Opti_9seg_notail_w62_shaped_Full_1Hz_5

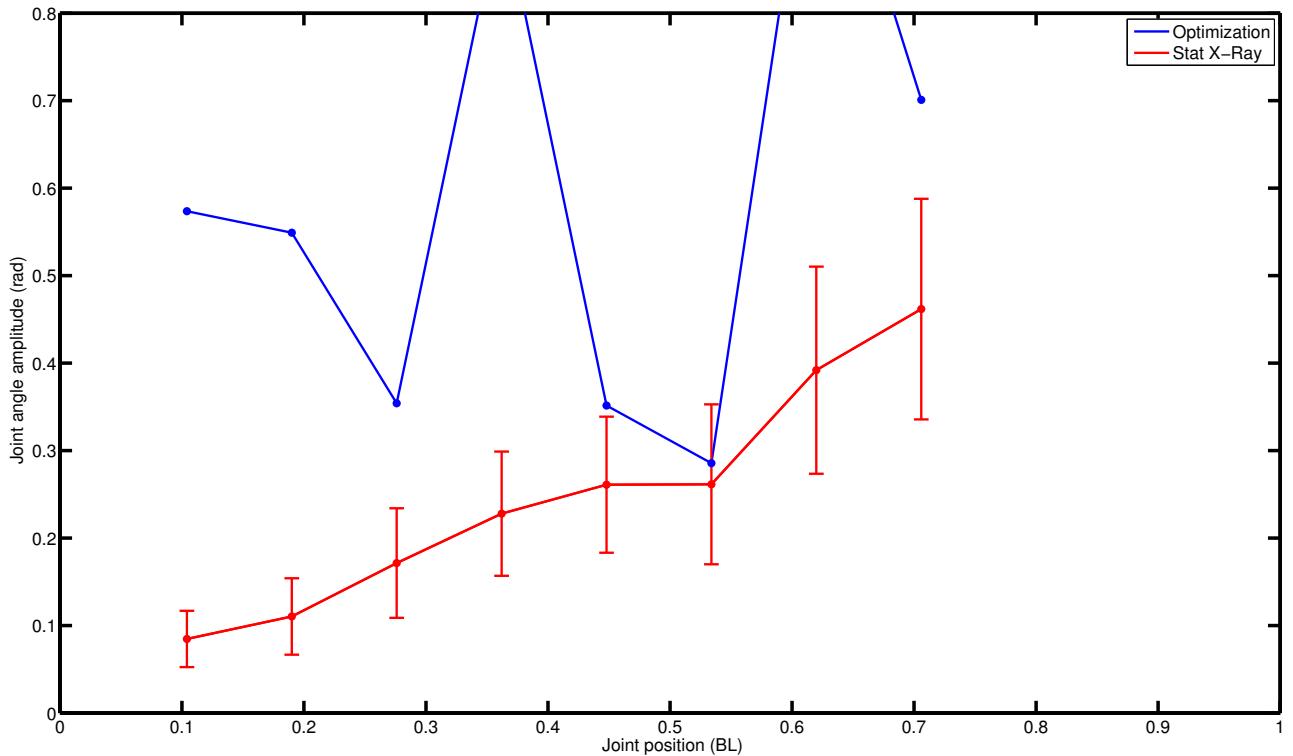


Figure 14.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Full_1Hz_5

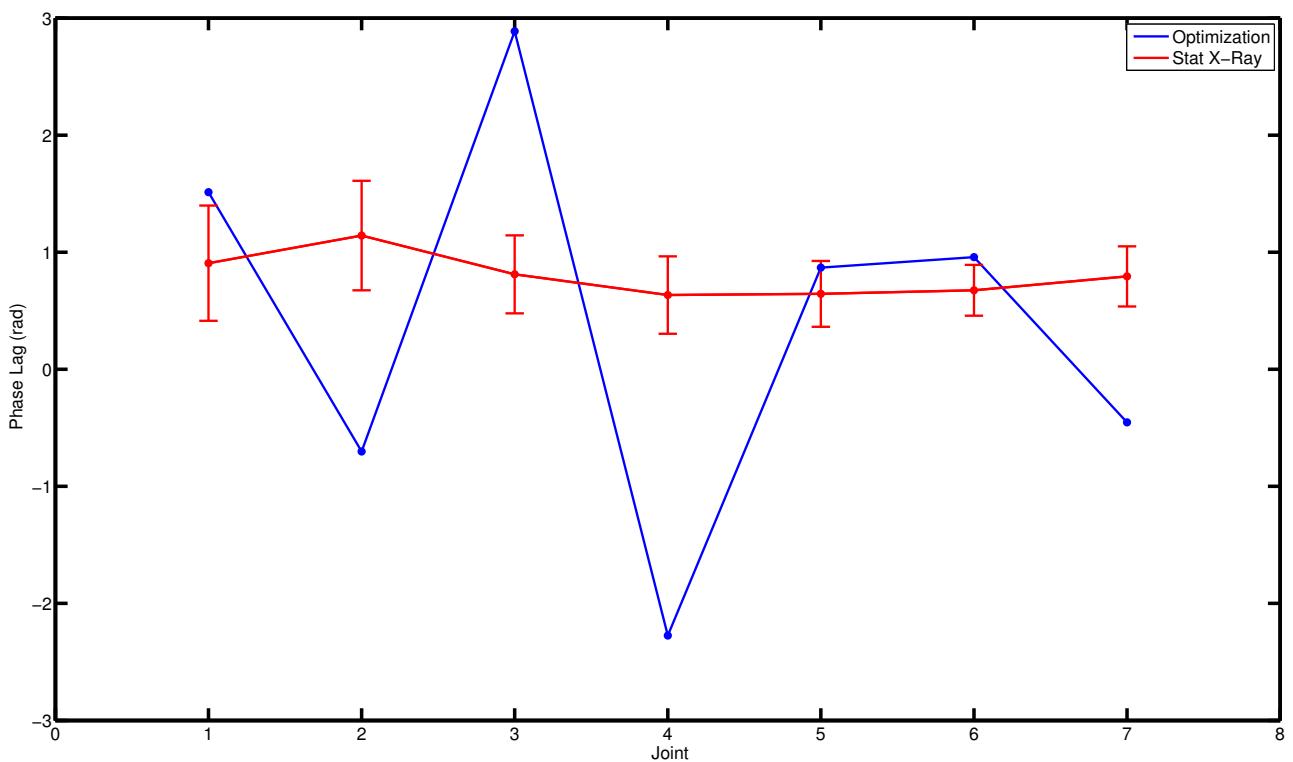


Figure 14.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Full_1Hz_5

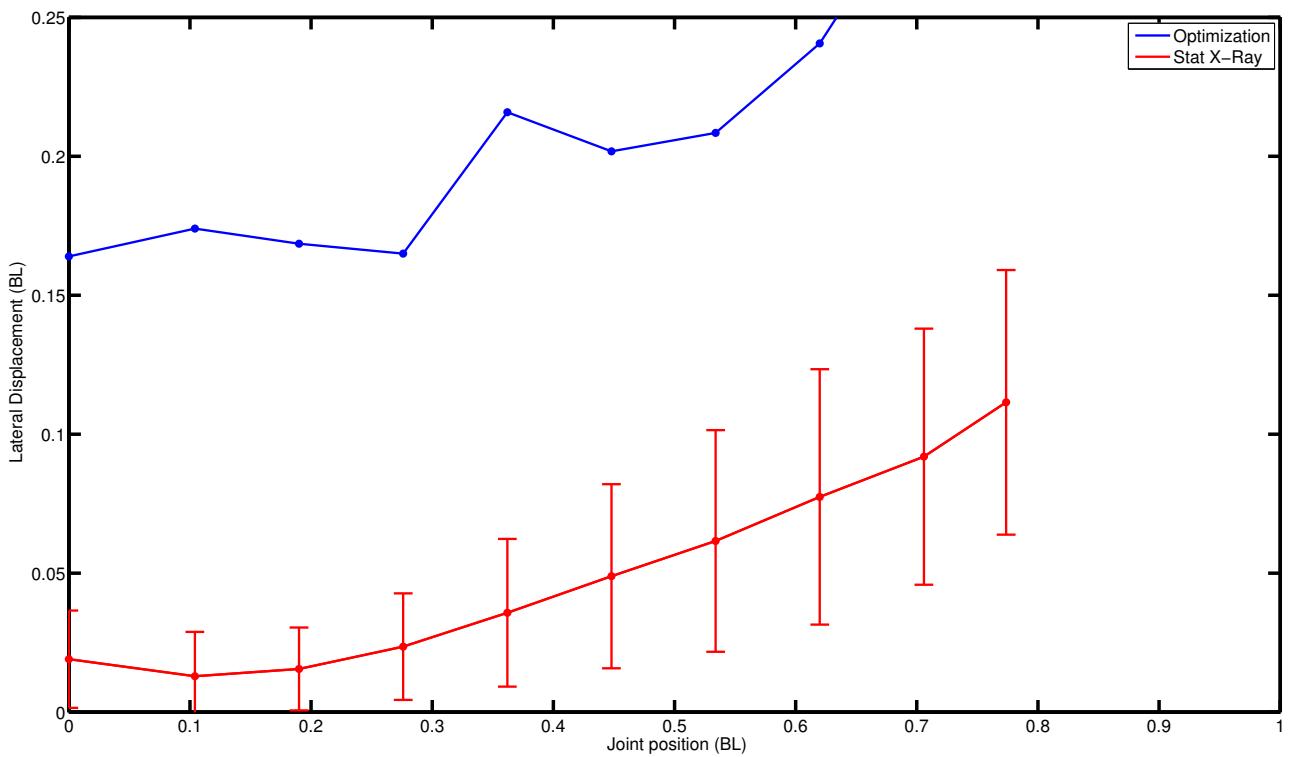


Figure 14.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Full_1Hz_5

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.164	NaN	NaN
Joint 1	0.174	0.574	NaN
Joint 2	0.169	0.549	1.512
Joint 3	0.165	0.354	-0.702
Joint 4	0.216	0.928	2.887
Joint 5	0.202	0.351	-2.275
Joint 6	0.208	0.286	0.868
Joint 7	0.241	1.083	0.958
Joint 8	0.298	0.701	-0.454
Joint 9	0.366	NaN	NaN

Table 14.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
-0.205	-0.232	1.134

Table 14.3: Speed data

14.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Full_1Hz_5/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_5.mp4

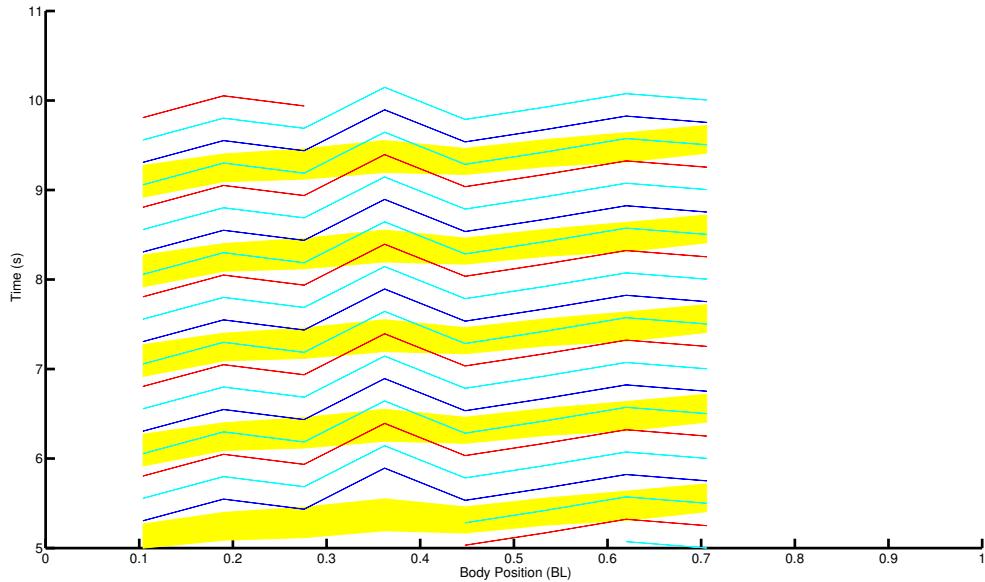


Figure 14.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Full_1Hz_5

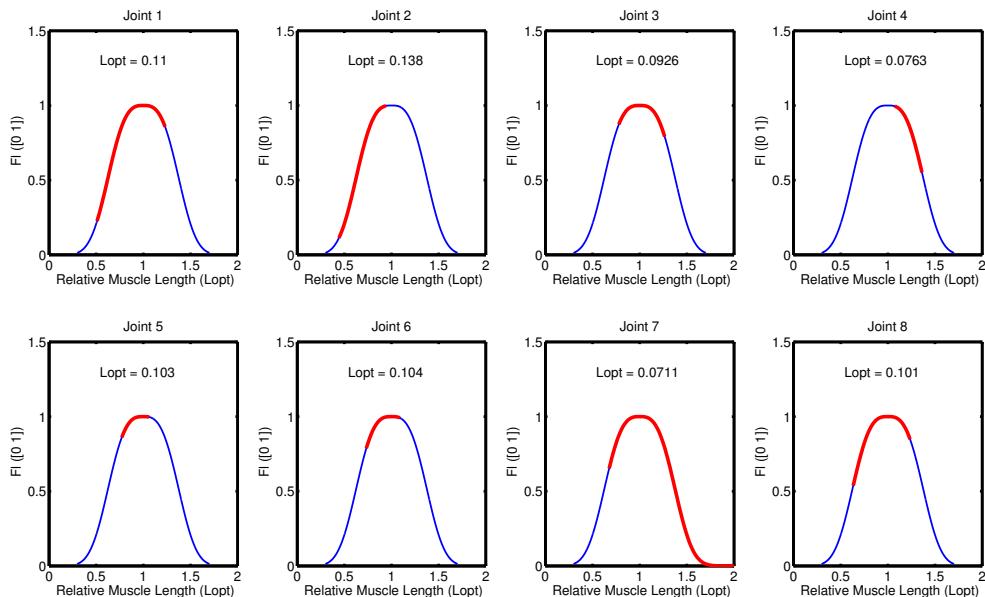


Figure 14.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Full_1Hz_5

14.3 Energy

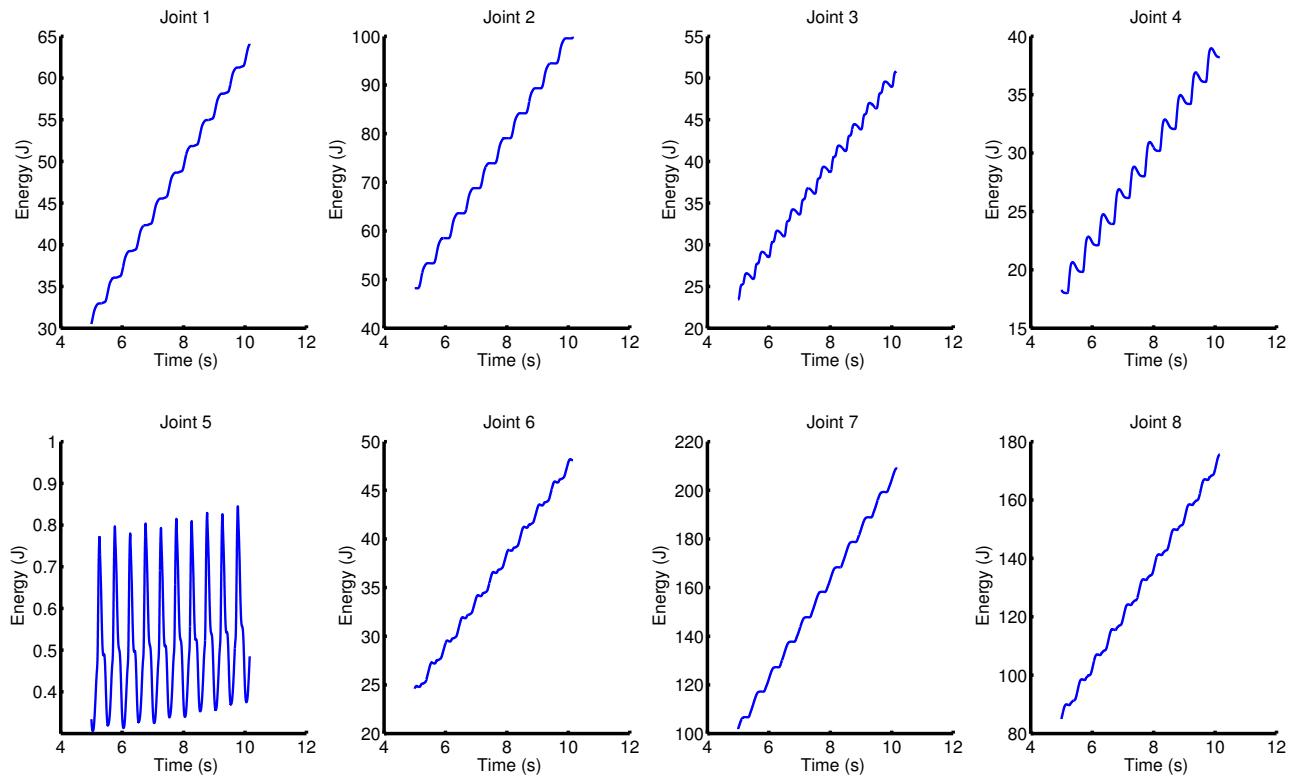


Figure 14.7: Energy_Opti_9seg_notail_w62_shaped_Full_1Hz_5

15 Opti_9seg_tail_w62_shaped_Full_1Hz_1

15.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_1/Opti_9seg_tail_w62_shaped_Full_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	52.202	5.720	195.530	145.184	84.249	100.577	127.939	135.978
Lopt (m)	0.070	0.072	0.075	0.085	0.101	0.092	0.107	0.103
r (m)	0.135	0.131	0.134	0.126	0.135	0.093	0.134	0.113
TimeLag (s)	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.749
error	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
Fitness	8.194	8.194	8.194	8.194	8.194	8.194	8.194	8.194

Table 15.1: Optimised Parameters

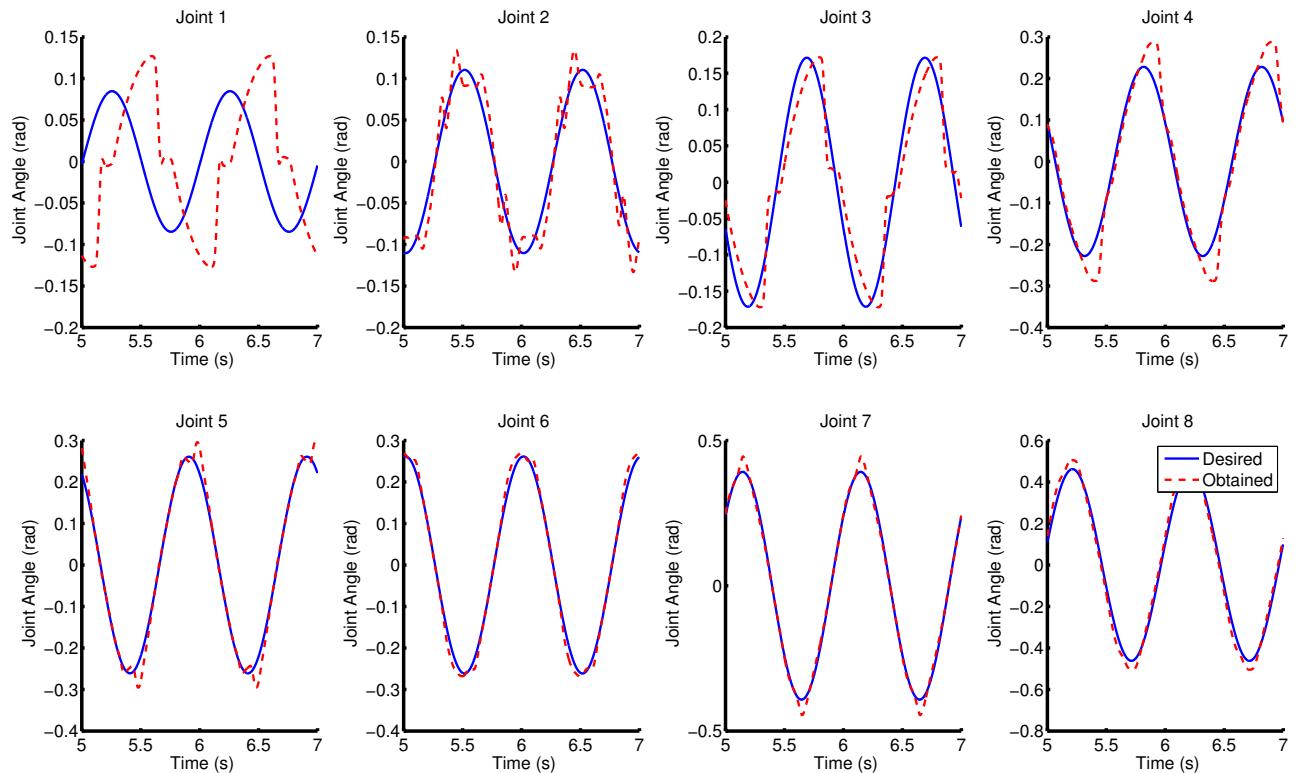


Figure 15.1: AngleDiff_Opti_9seg_tail_w62_shaped_Full_1Hz_1

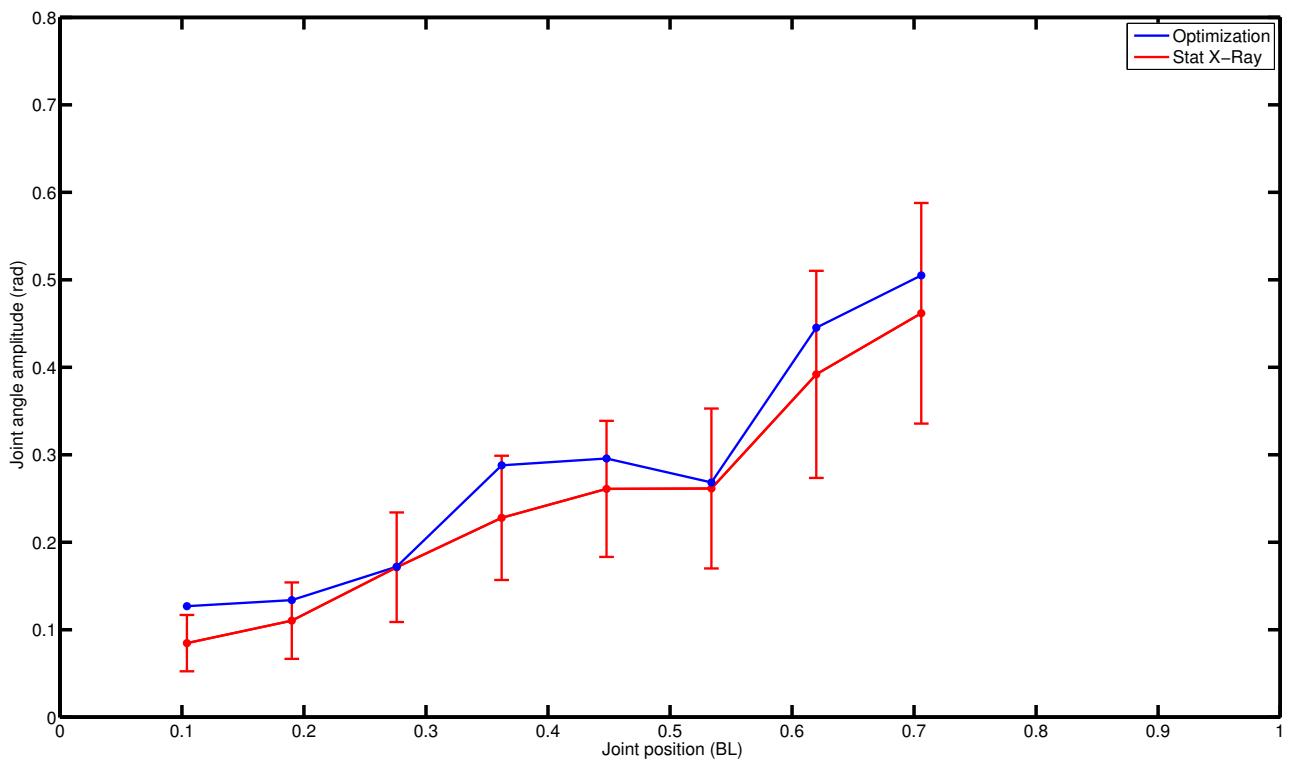


Figure 15.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Full_1Hz_1

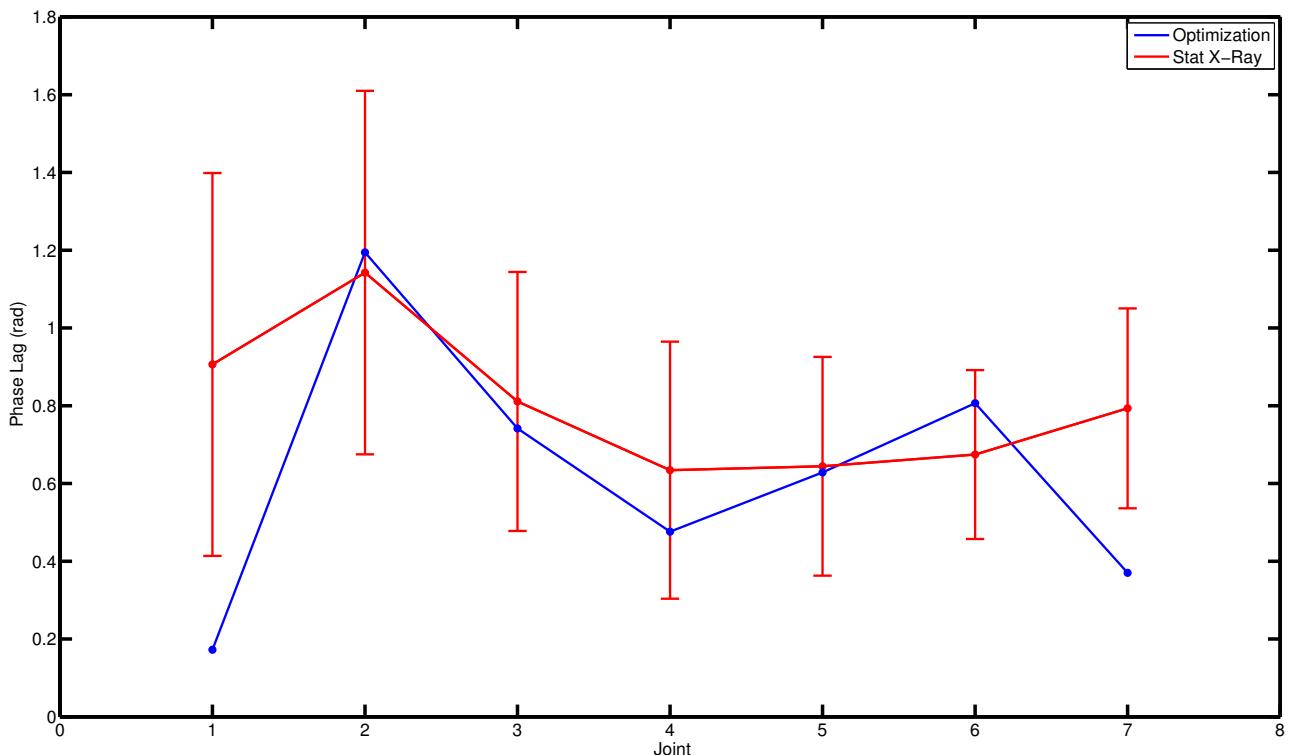


Figure 15.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Full_1Hz_1

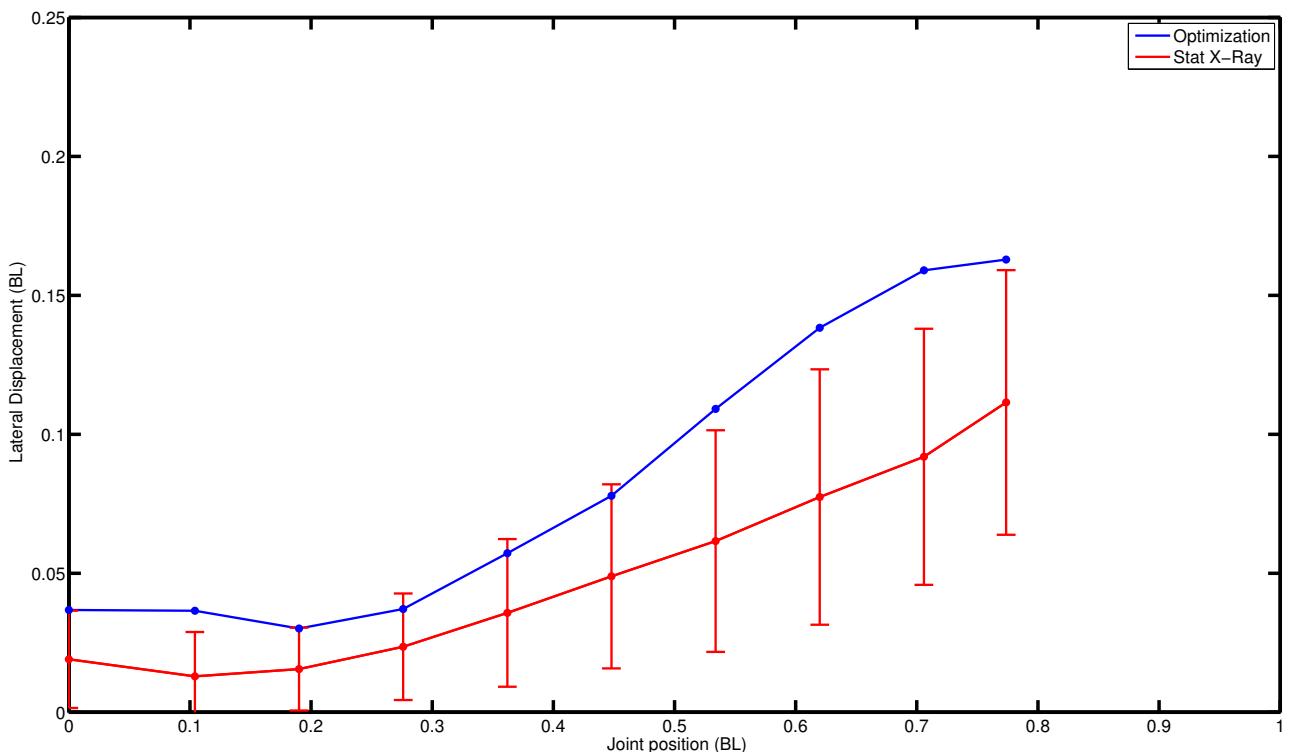


Figure 15.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Full_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.037	NaN	NaN
Joint 1	0.037	0.127	NaN
Joint 2	0.030	0.134	0.172
Joint 3	0.037	0.172	1.194
Joint 4	0.057	0.288	0.742
Joint 5	0.078	0.296	0.476
Joint 6	0.109	0.268	0.628
Joint 7	0.138	0.445	0.806
Joint 8	0.159	0.505	0.370
Joint 9	0.163	NaN	NaN

Table 15.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.528	0.834	1.580

Table 15.3: Speed data

15.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_1.mp4

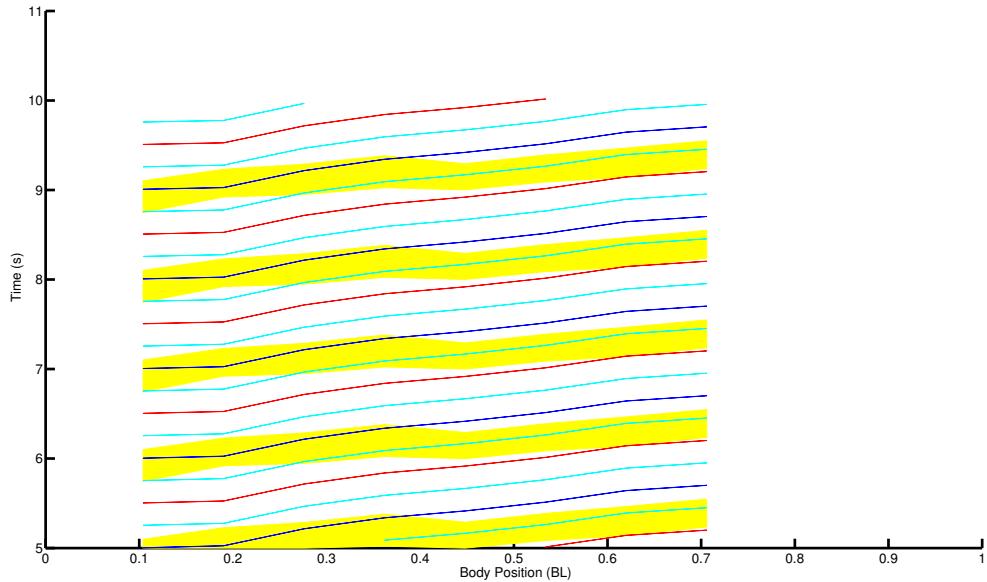


Figure 15.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_1

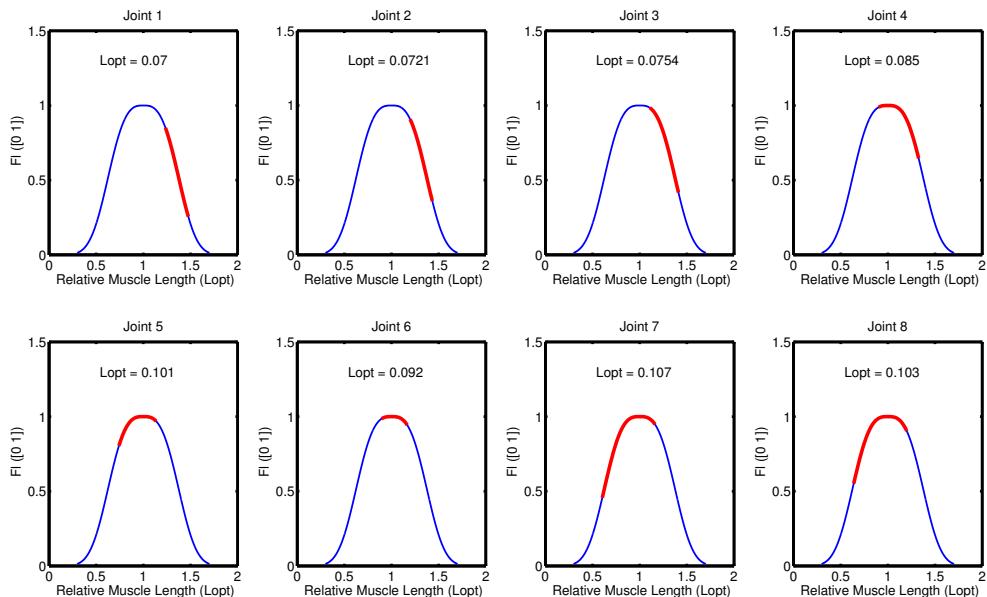


Figure 15.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Full_1Hz_1

15.3 Energy

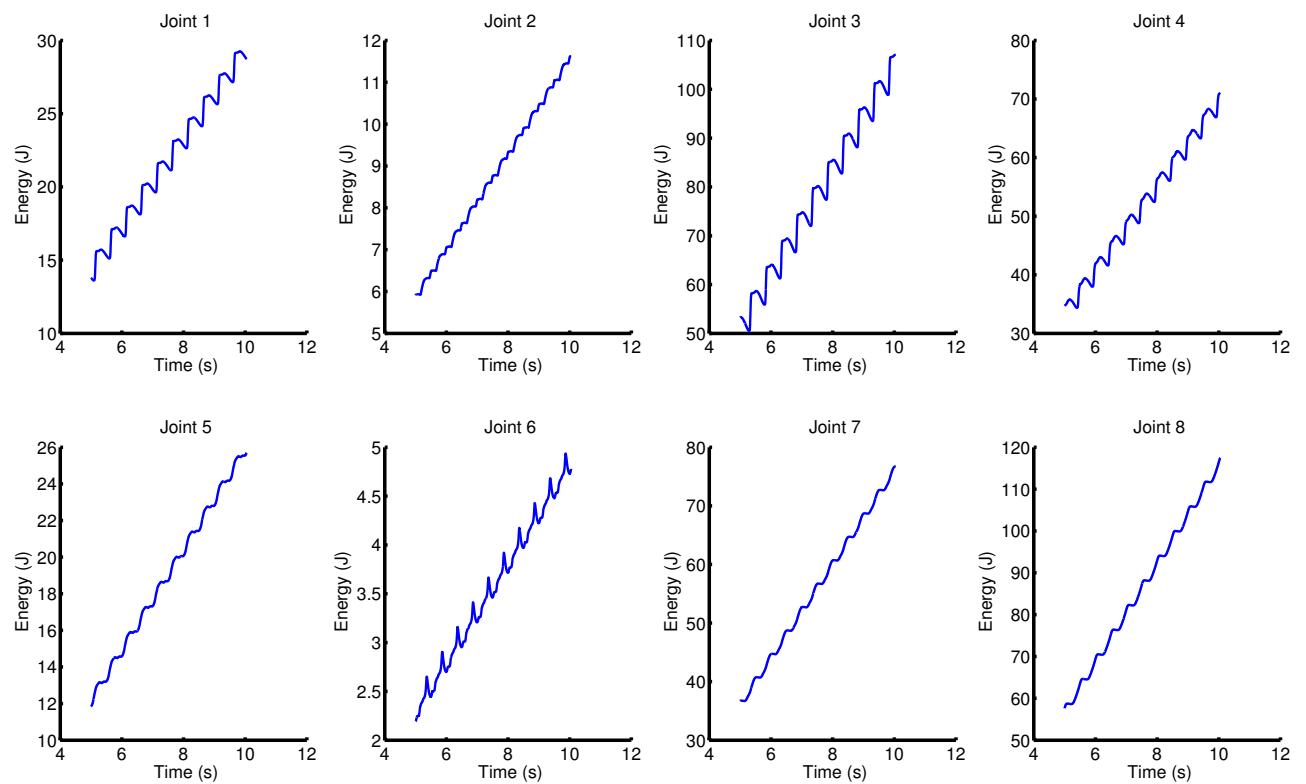


Figure 15.7: Energy_Opti_9seg_tail_w62_shaped_Full_1Hz_1

16 Opti_9seg_tail_w62_shaped_Full_1Hz_2

16.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_2/Opti_9seg_tail_w62_shaped_Full_1Hz_2.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	66.356	6.924	90.091	115.261	73.617	93.096	96.719	117.690
Lopt (m)	0.070	0.072	0.078	0.083	0.100	0.093	0.098	0.105
r (m)	0.137	0.087	0.130	0.133	0.131	0.099	0.108	0.129
TimeLag (s)	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746
error	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
Fitness	8.803	8.803	8.803	8.803	8.803	8.803	8.803	8.803

Table 16.1: Optimised Parameters

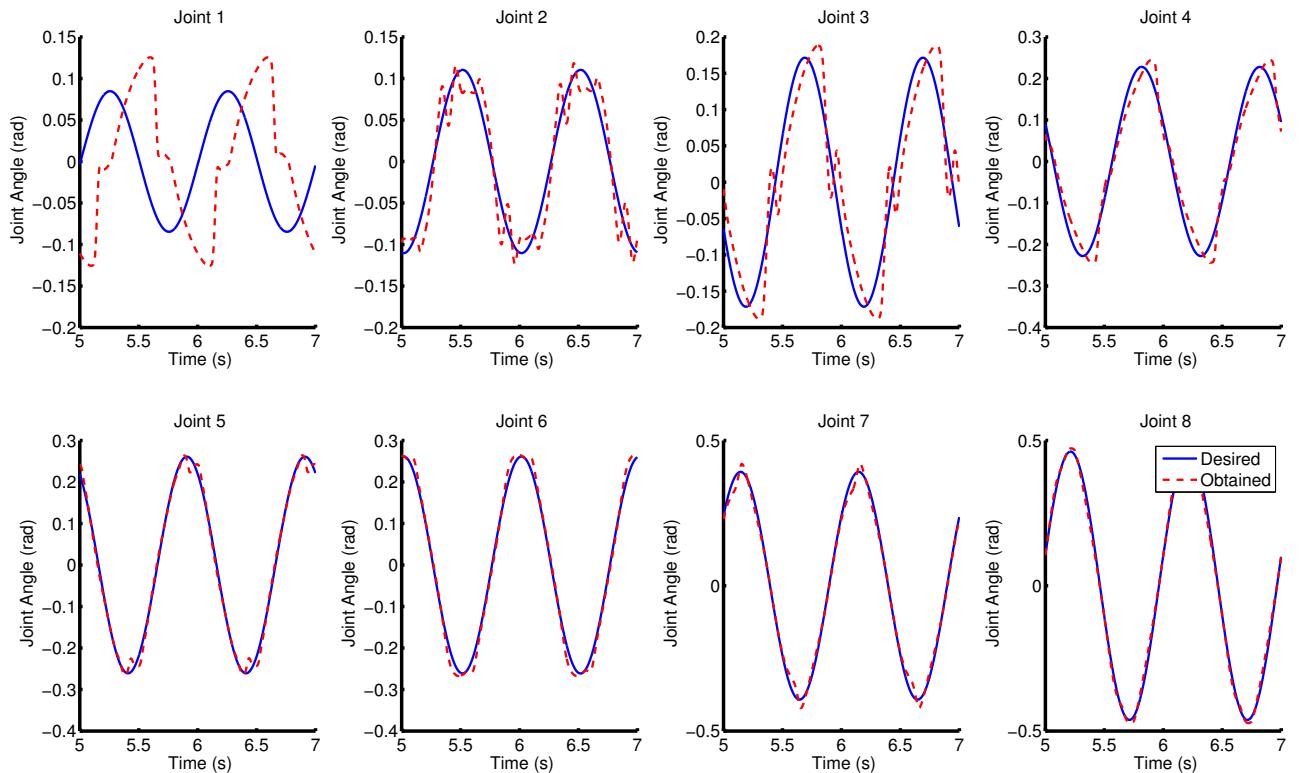


Figure 16.1: AngleDiff_Opti_9seg_tail_w62_shaped_Full_1Hz_2

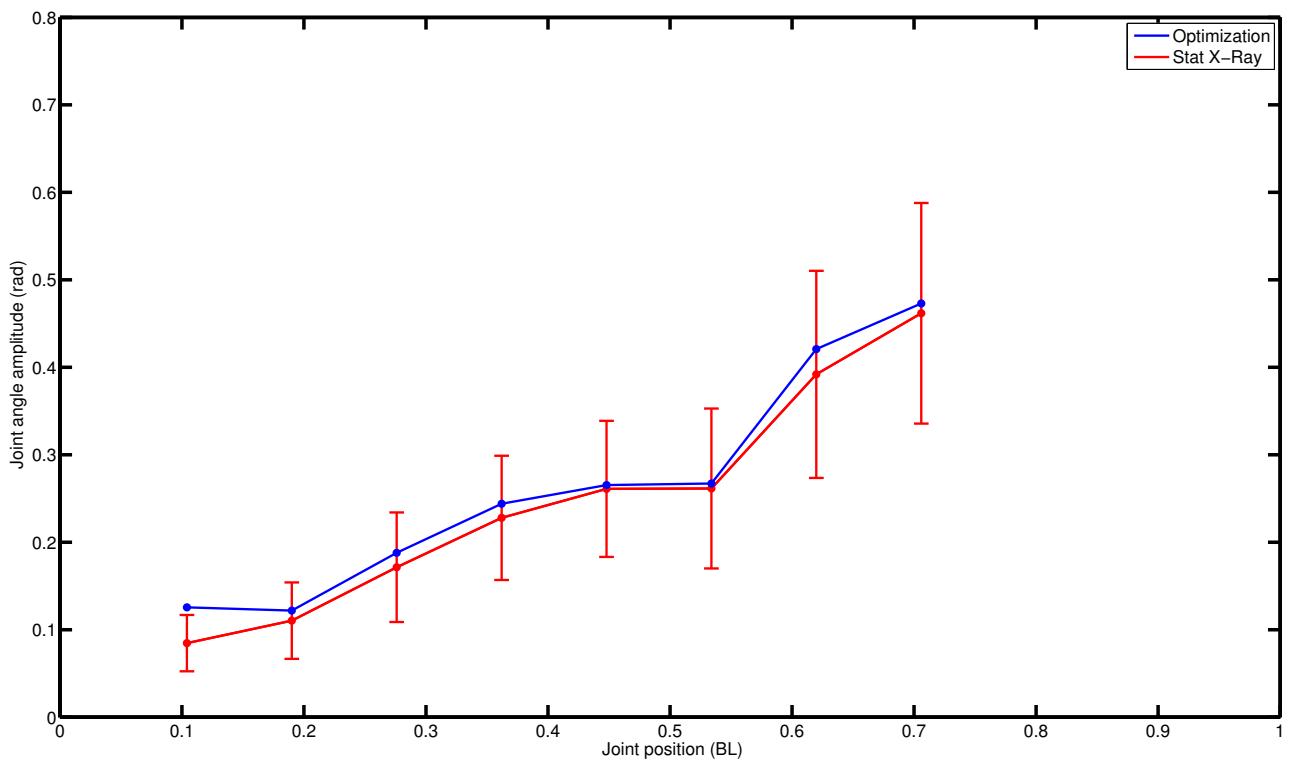


Figure 16.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Full_1Hz_2

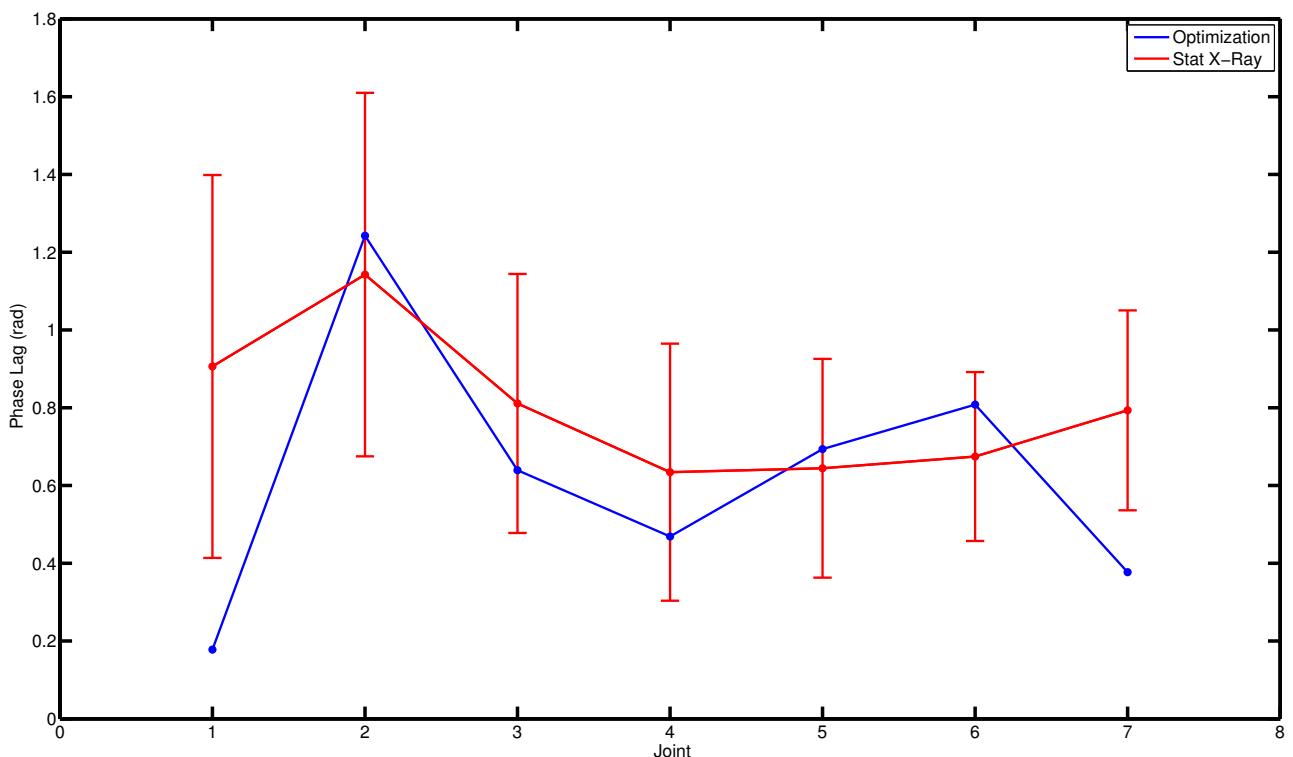


Figure 16.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Full_1Hz_2

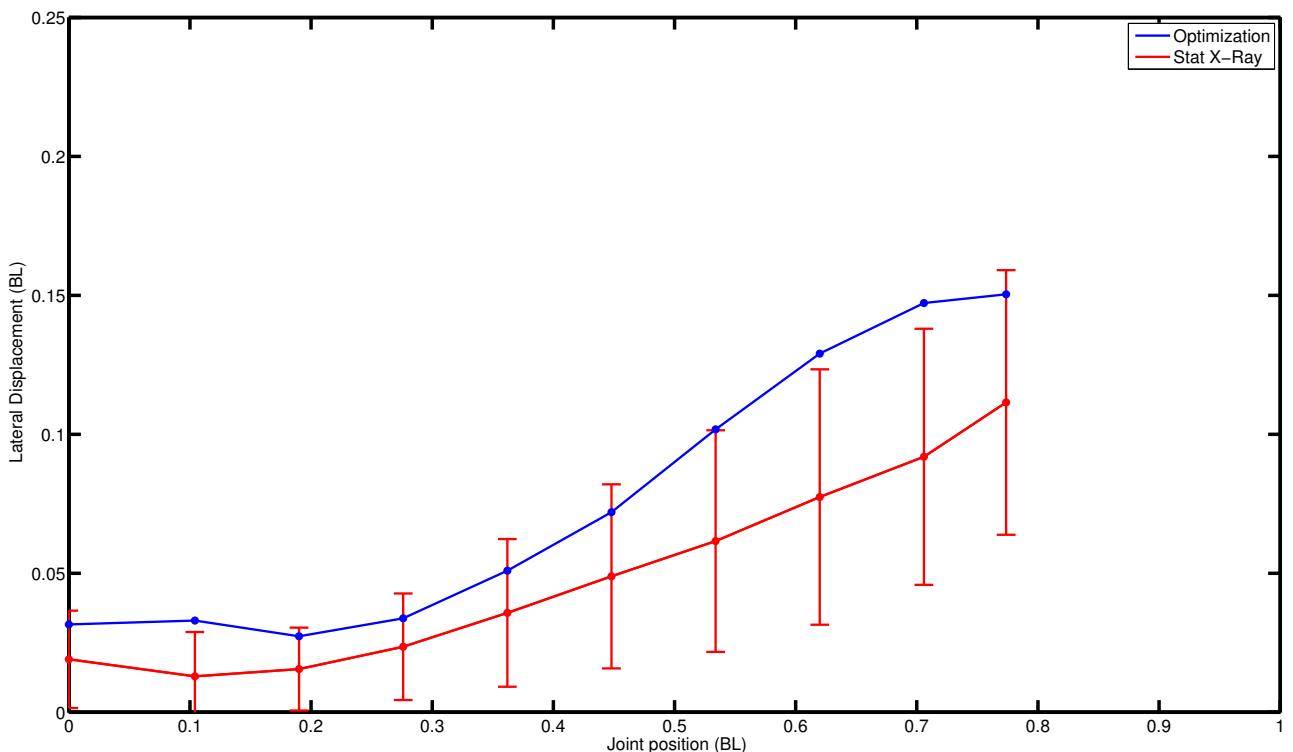


Figure 16.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Full_1Hz_2

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.032	NaN	NaN
Joint 1	0.033	0.126	NaN
Joint 2	0.027	0.122	0.178
Joint 3	0.034	0.188	1.243
Joint 4	0.051	0.244	0.639
Joint 5	0.072	0.265	0.469
Joint 6	0.102	0.267	0.694
Joint 7	0.129	0.421	0.808
Joint 8	0.147	0.473	0.377
Joint 9	0.150	NaN	NaN

Table 16.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.505	0.932	1.846

Table 16.3: Speed data

16.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_2/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_2.mp4

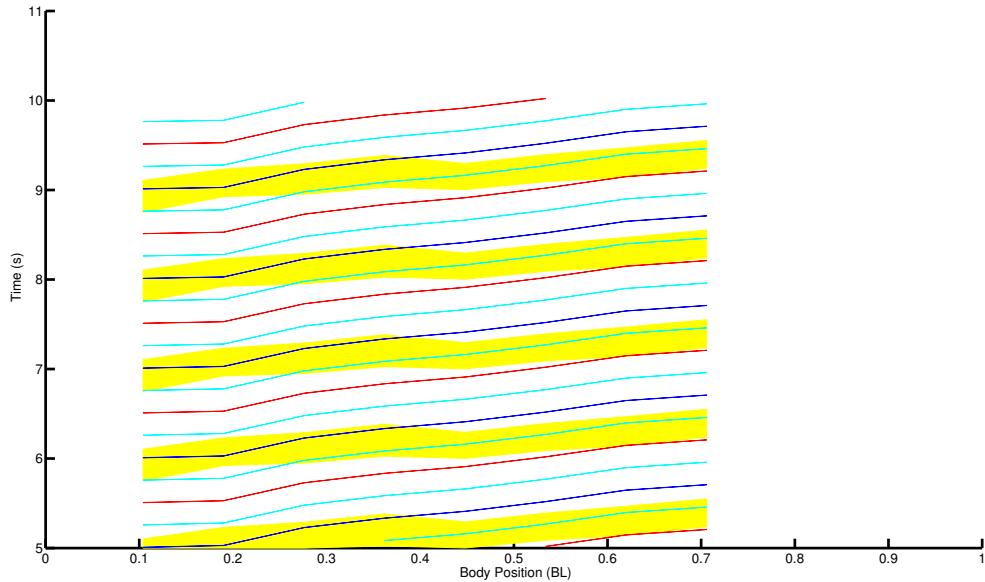


Figure 16.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_2

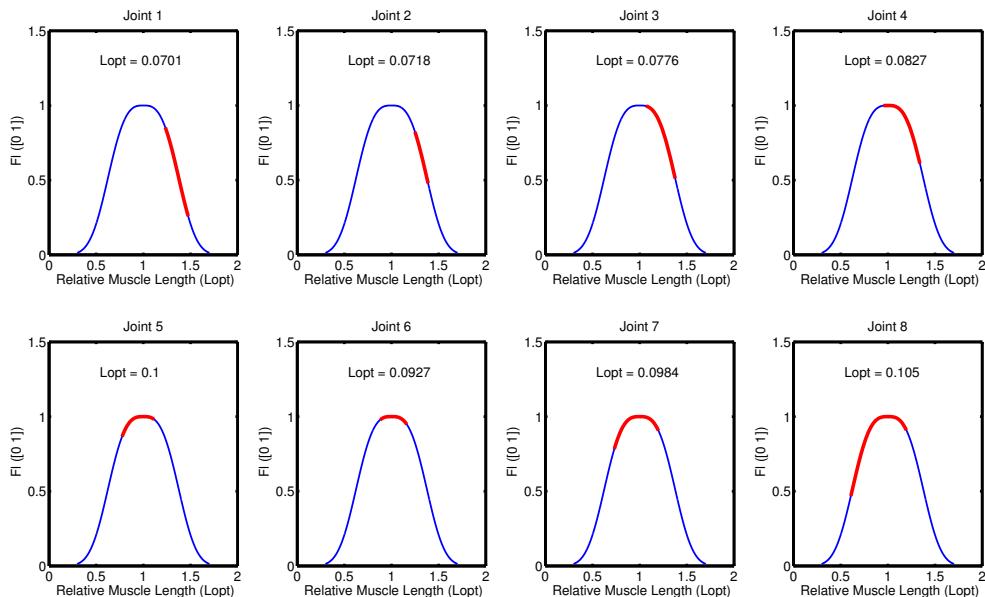


Figure 16.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Full_1Hz_2

16.3 Energy

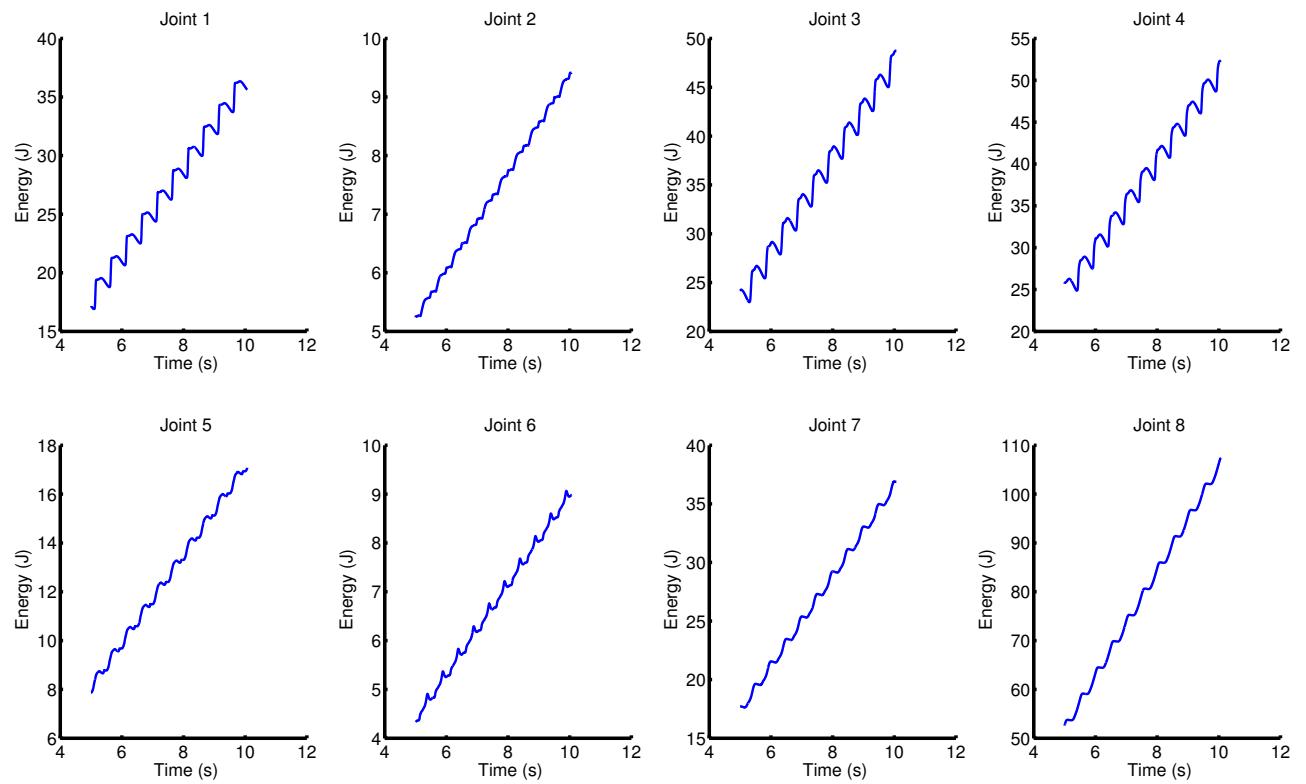


Figure 16.7: Energy_Opti_9seg_tail_w62_shaped_Full_1Hz_2

17 Opti_9seg_tail_w62_shaped_Full_1Hz_3

17.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_3/Opti_9seg_tail_w62_shaped_Full_1Hz_3.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	93.066	134.846	153.712	68.939	53.475	62.750	90.303	105.097
Lopt (m)	0.070	0.070	0.078	0.080	0.103	0.097	0.107	0.109
r (m)	0.139	0.139	0.128	0.102	0.133	0.119	0.123	0.133
TimeLag (s)	0.771	0.771	0.771	0.771	0.771	0.771	0.771	0.771
error	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
Fitness	8.219	8.219	8.219	8.219	8.219	8.219	8.219	8.219

Table 17.1: Optimised Parameters

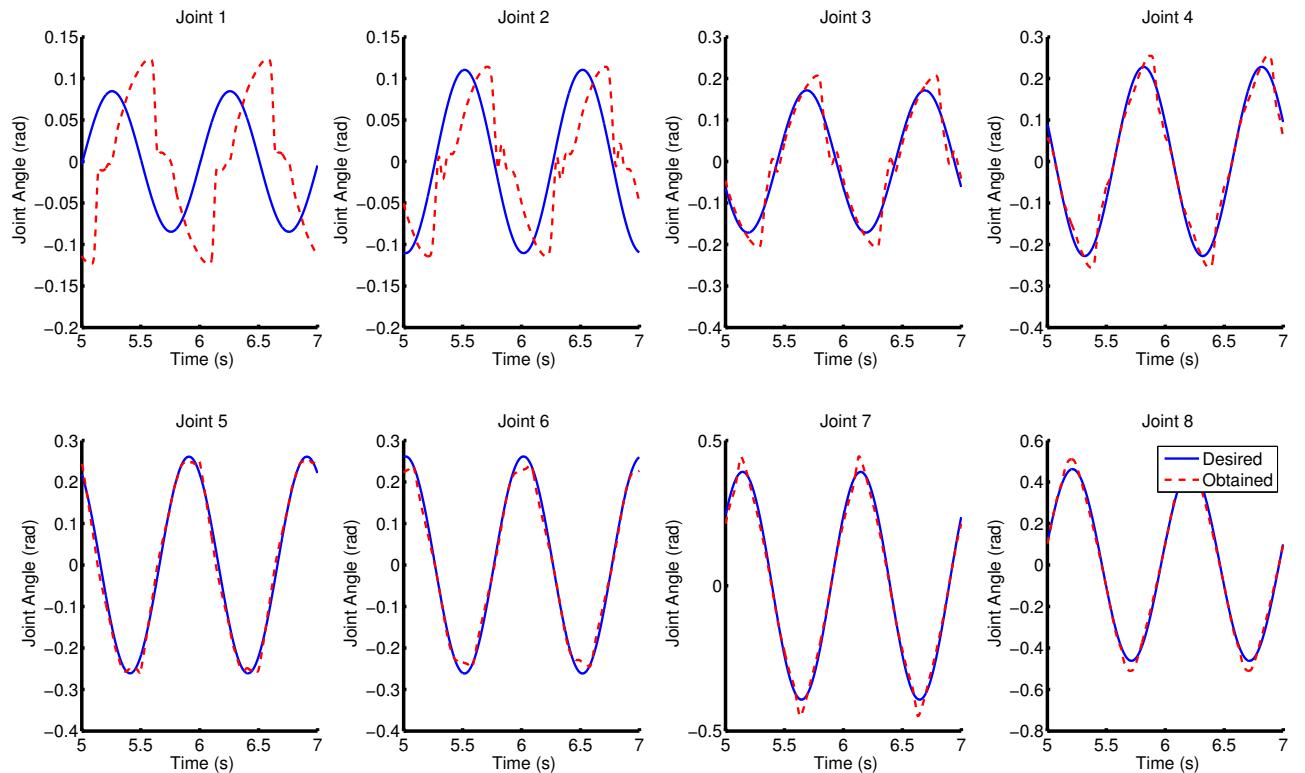


Figure 17.1: AngleDiff_Opti_9seg_tail_w62_shaped_Full_1Hz_3

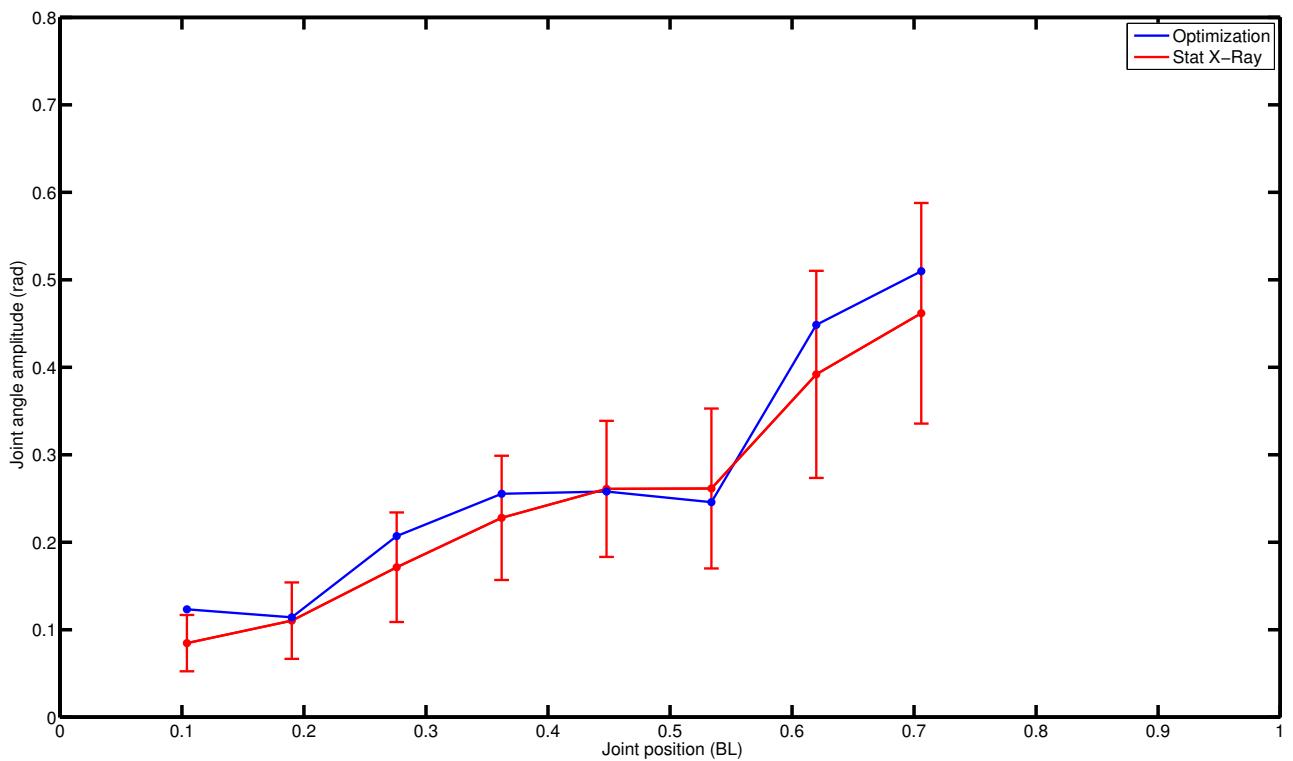


Figure 17.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Full_1Hz_3

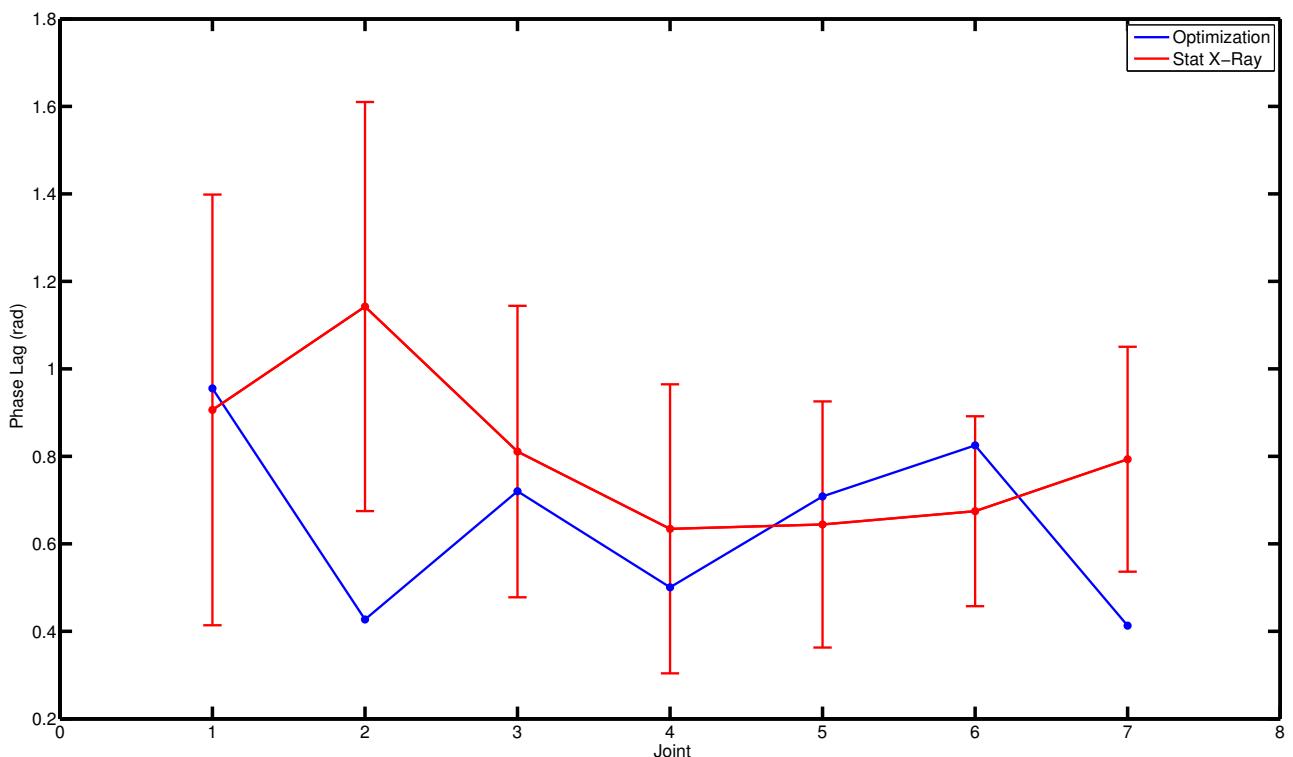


Figure 17.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Full_1Hz_3

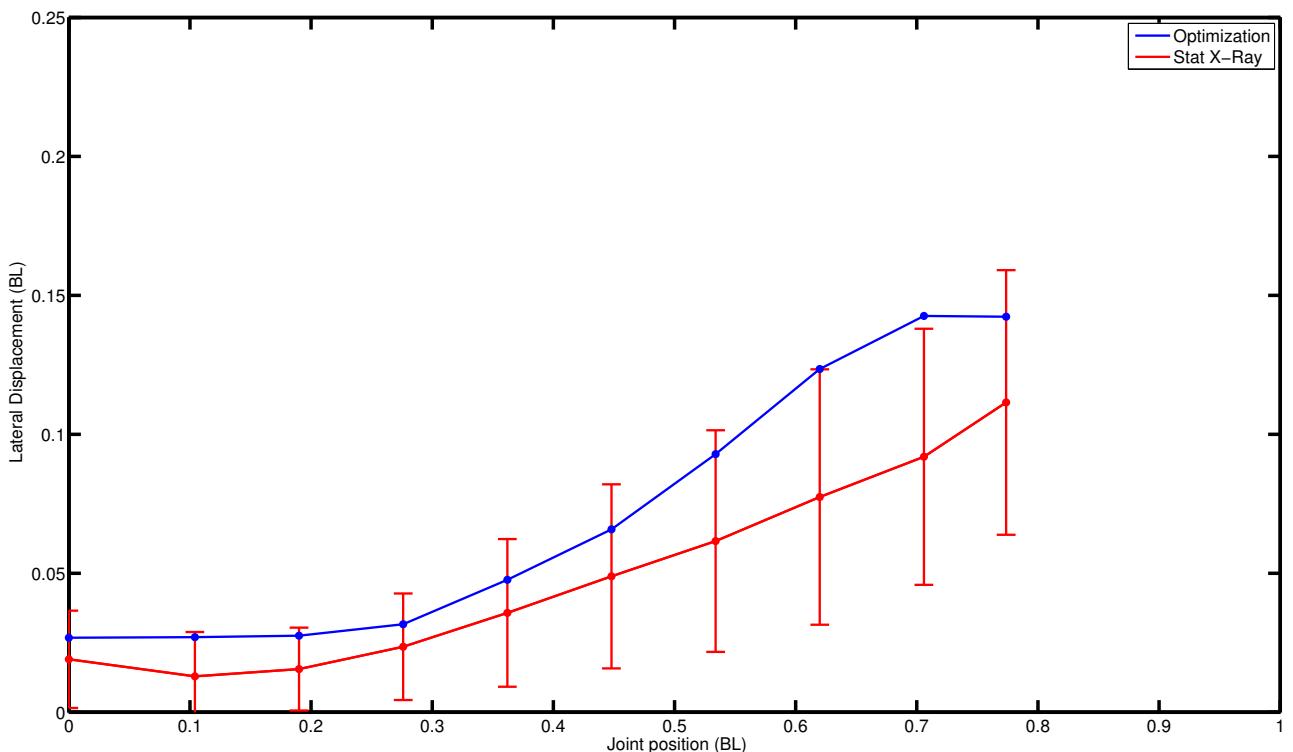


Figure 17.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Full_1Hz_3

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.027	NaN	NaN
Joint 1	0.027	0.123	NaN
Joint 2	0.028	0.114	0.955
Joint 3	0.032	0.207	0.427
Joint 4	0.048	0.255	0.720
Joint 5	0.066	0.258	0.500
Joint 6	0.093	0.246	0.708
Joint 7	0.124	0.448	0.825
Joint 8	0.143	0.510	0.413
Joint 9	0.142	NaN	NaN

Table 17.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.487	1.034	2.125

Table 17.3: Speed data

17.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_3/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_3.mp4

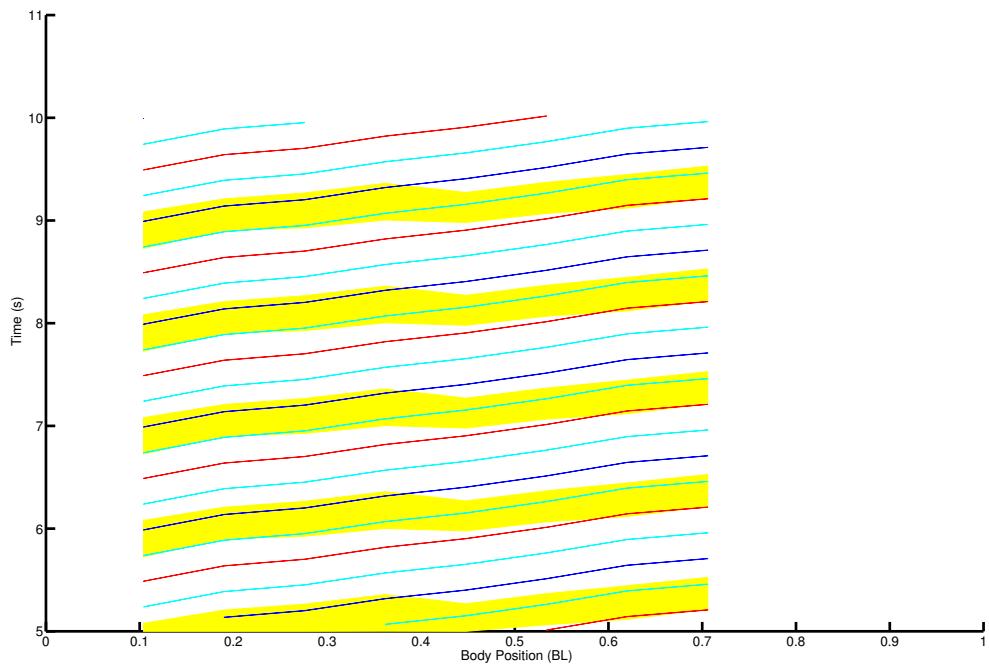


Figure 17.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_3

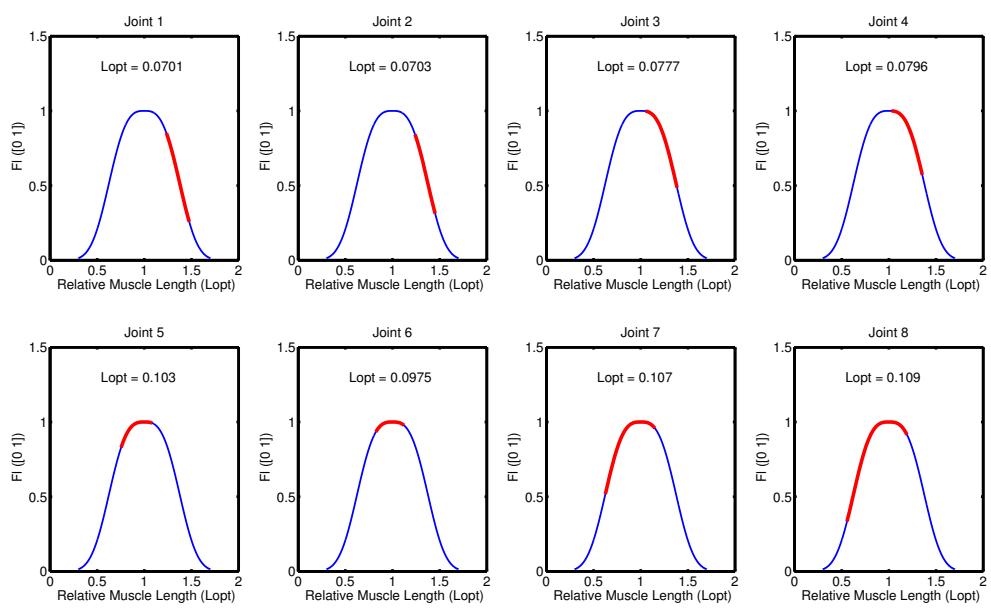


Figure 17.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Full_1Hz_3

17.3 Energy

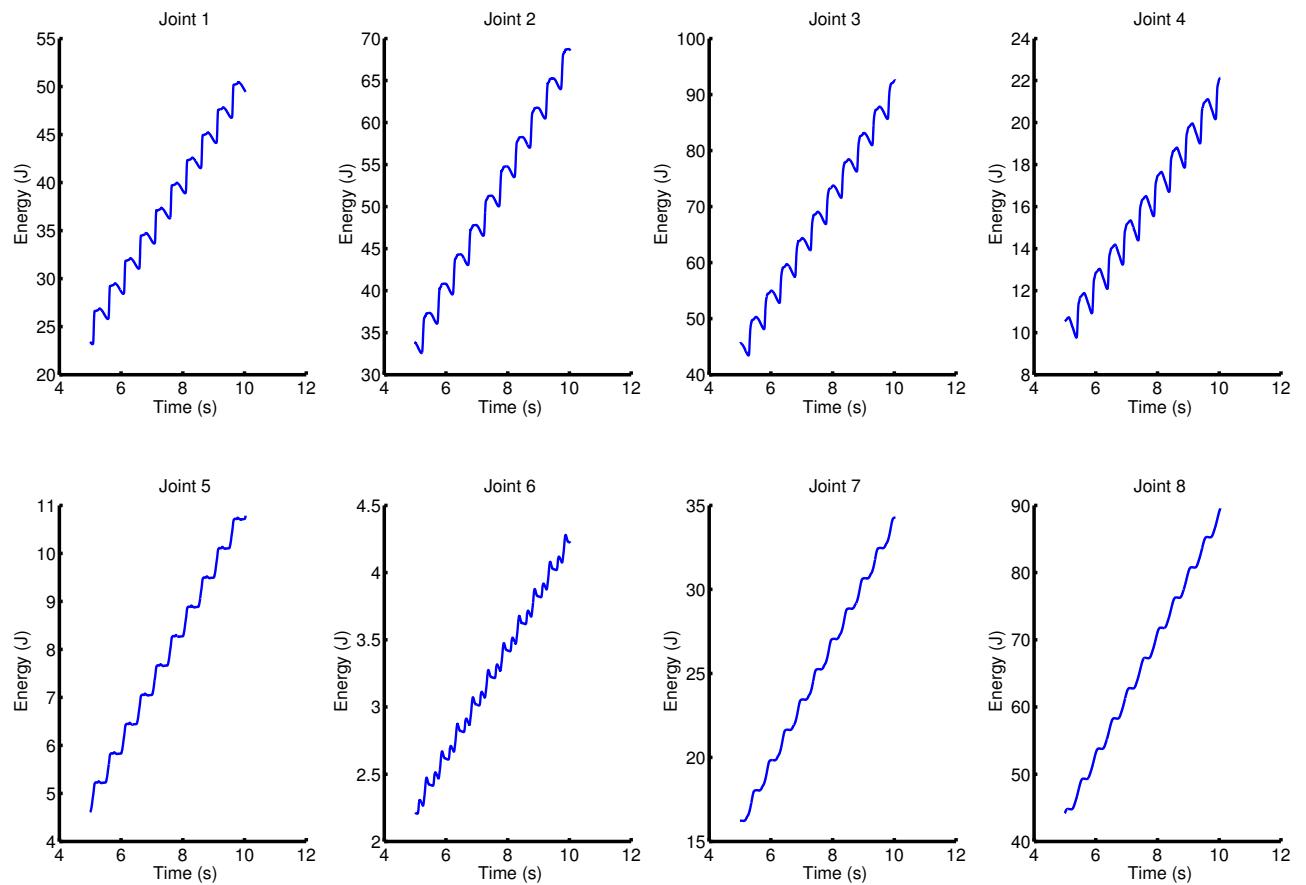


Figure 17.7: Energy_Opti_9seg_tail_w62_shaped_Full_1Hz_3

18 Opti_9seg_tail_w62_shaped_Full_1Hz_4

18.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_4/Opti_9seg_tail_w62_shaped_Full_1Hz_4.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	165.147	87.845	104.637	110.554	60.438	67.591	75.726	62.276
Lopt (m)	0.070	0.070	0.076	0.087	0.102	0.098	0.088	0.097
r (m)	0.135	0.138	0.097	0.136	0.139	0.132	0.060	0.114
TimeLag (s)	0.779	0.779	0.779	0.779	0.779	0.779	0.779	0.779
error	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
Fitness	8.097	8.097	8.097	8.097	8.097	8.097	8.097	8.097

Table 18.1: Optimised Parameters

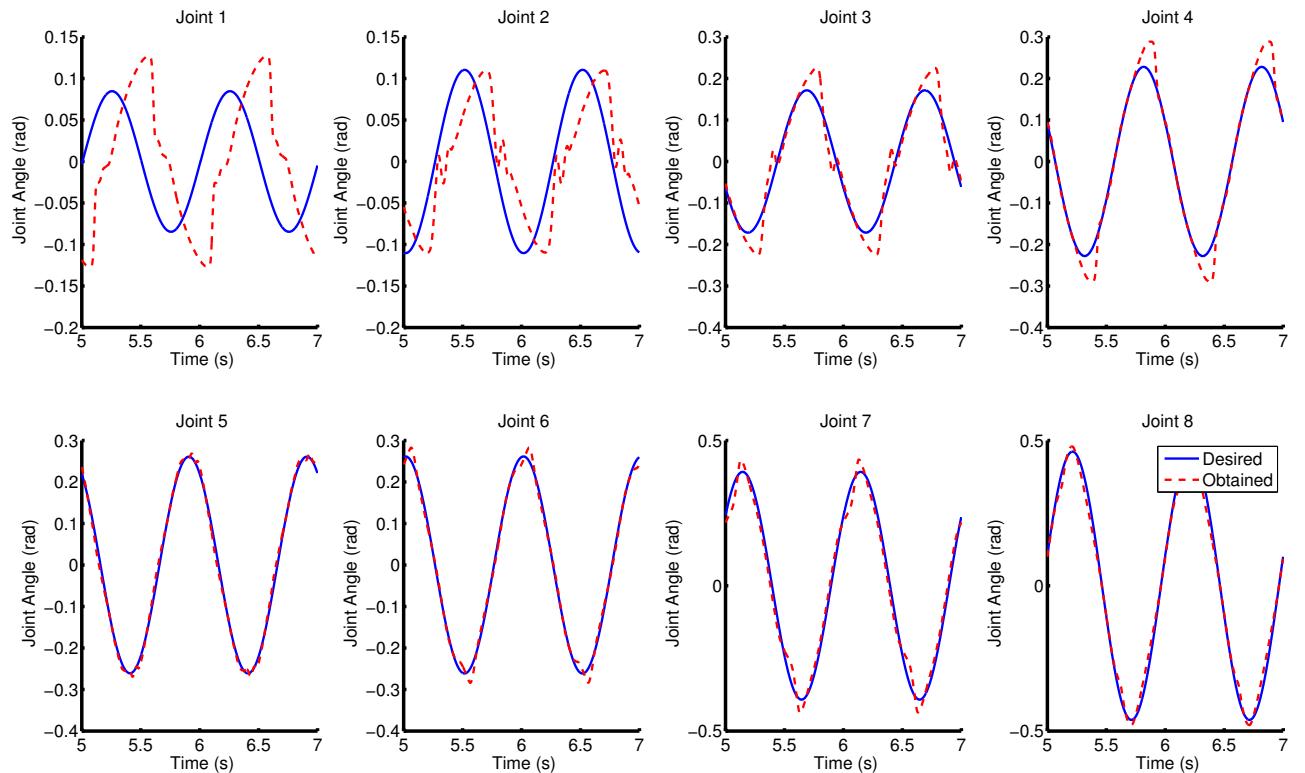


Figure 18.1: AngleDiff_Opti_9seg_tail_w62_shaped_Full_1Hz_4

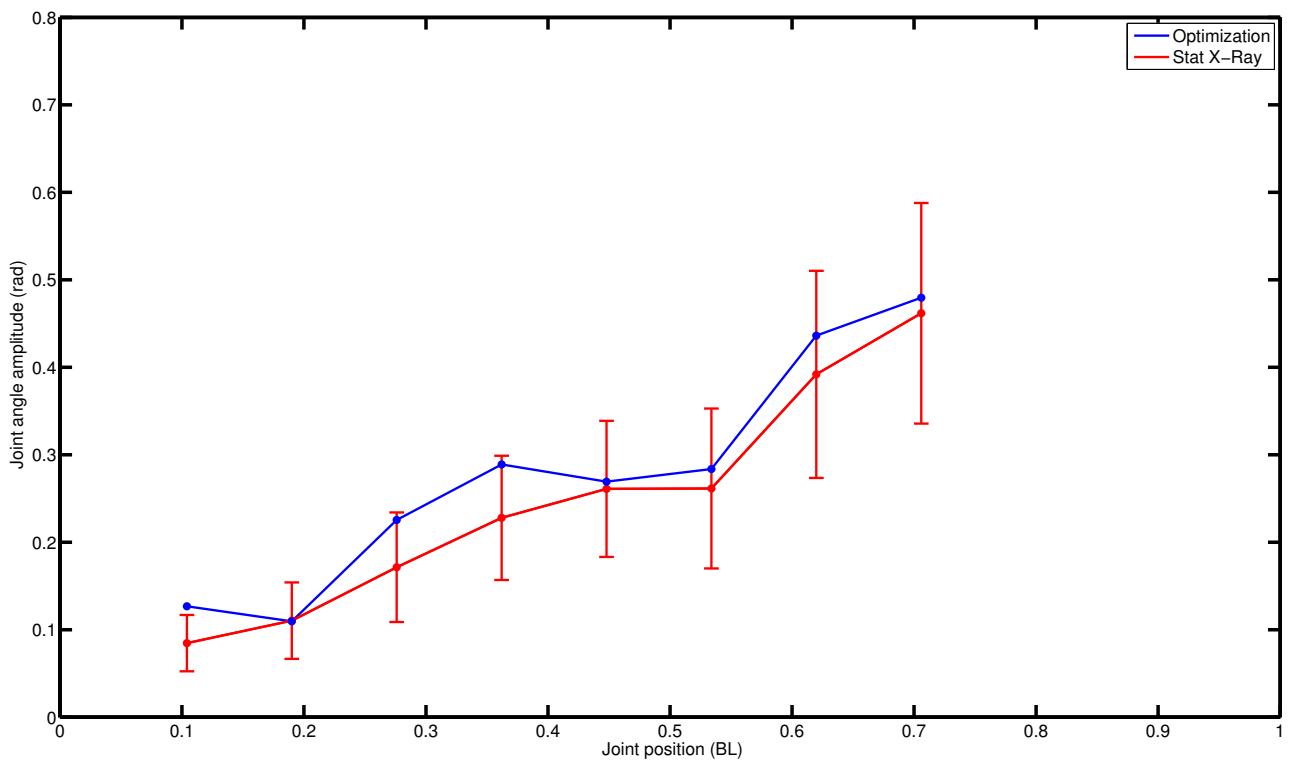


Figure 18.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Full_1Hz_4

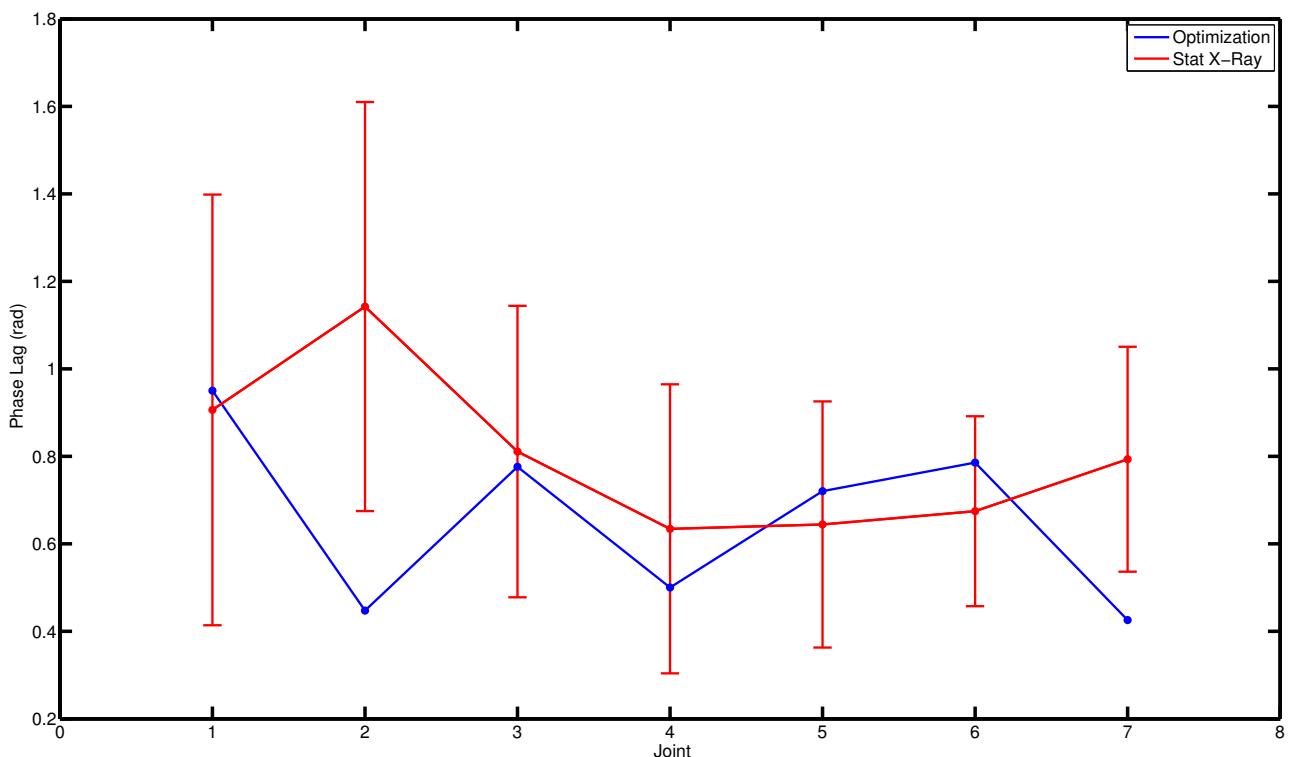


Figure 18.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Full_1Hz_4

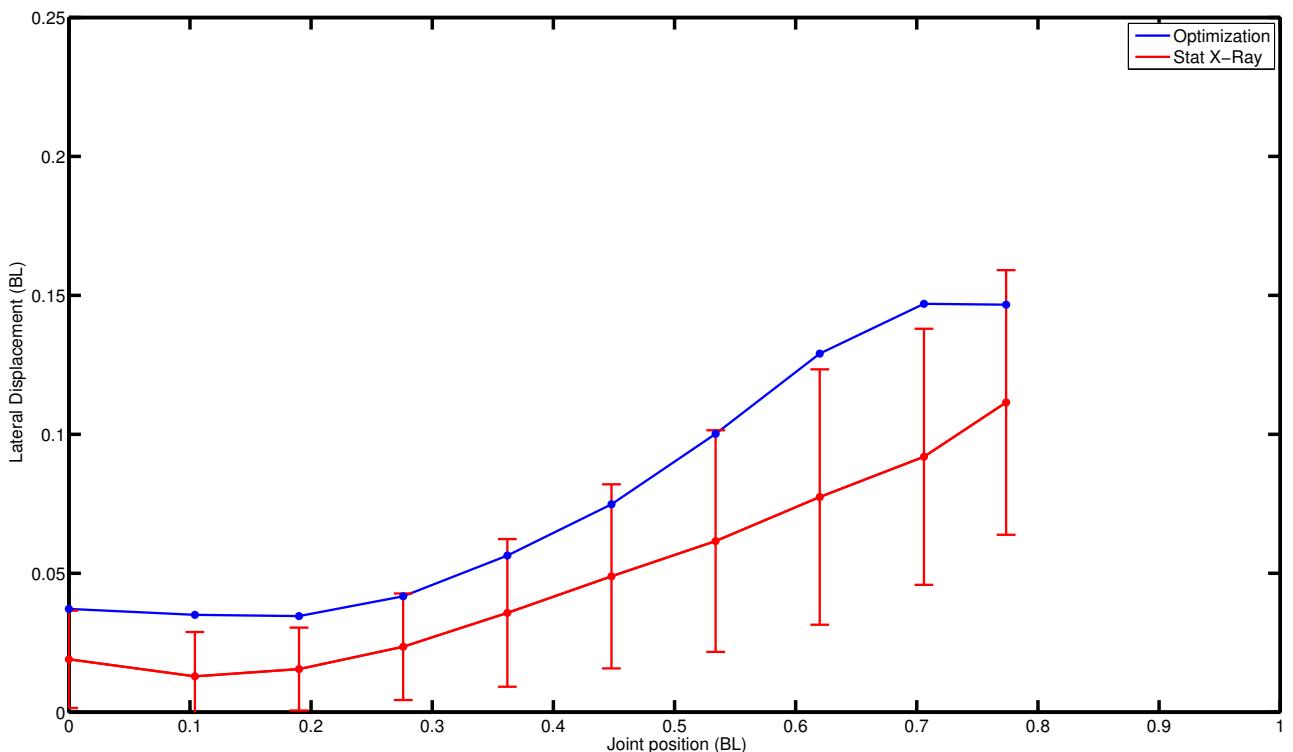


Figure 18.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Full_1Hz_4

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.037	NaN	NaN
Joint 1	0.035	0.127	NaN
Joint 2	0.035	0.110	0.950
Joint 3	0.042	0.225	0.447
Joint 4	0.056	0.289	0.776
Joint 5	0.075	0.269	0.500
Joint 6	0.100	0.284	0.720
Joint 7	0.129	0.436	0.786
Joint 8	0.147	0.480	0.426
Joint 9	0.147	NaN	NaN

Table 18.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.491	0.975	1.988

Table 18.3: Speed data

18.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_4/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_4.mp4

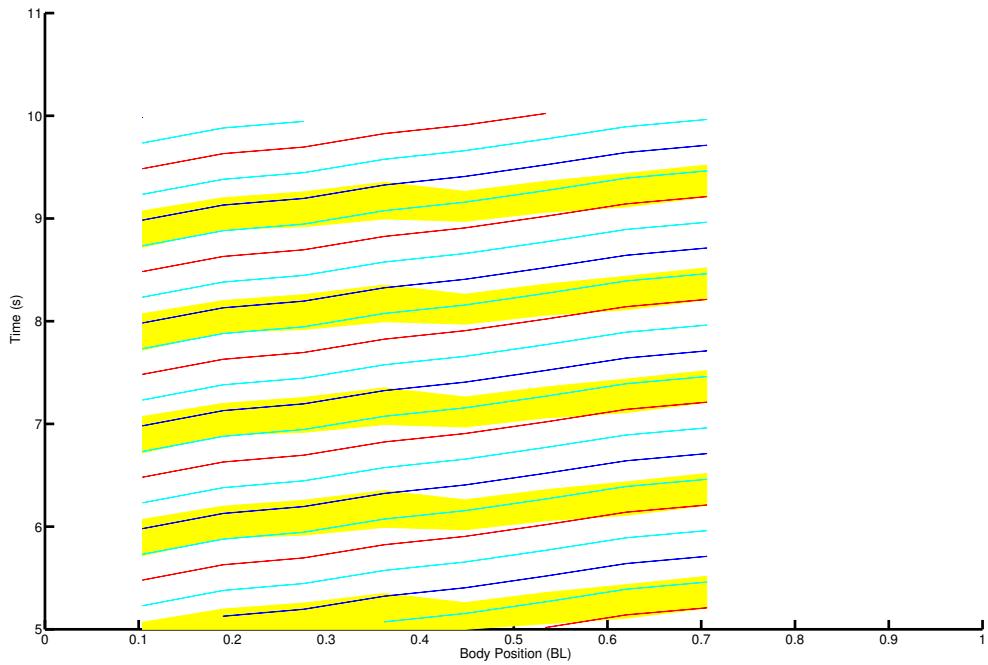


Figure 18.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_4

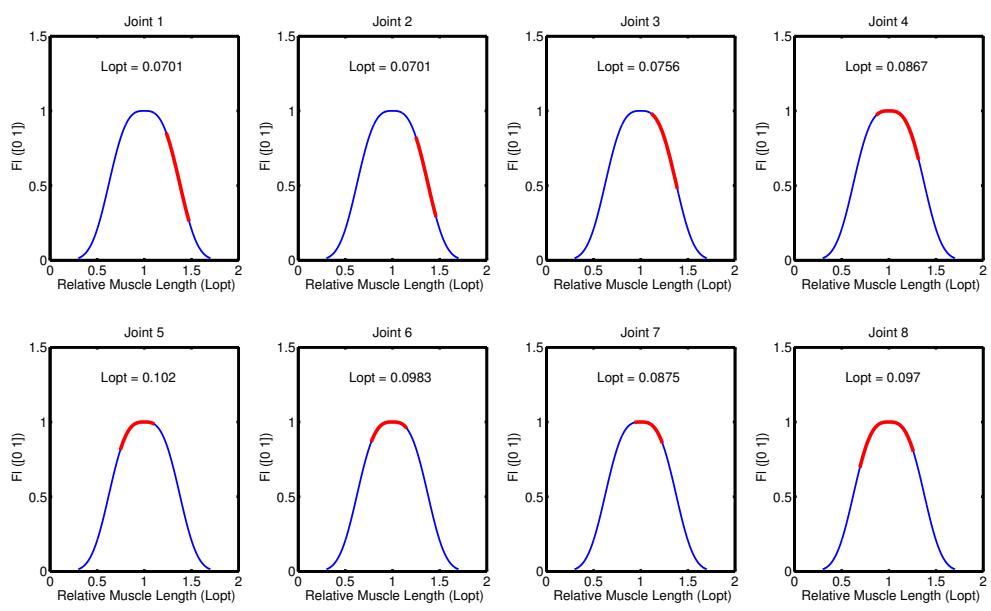


Figure 18.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Full_1Hz_4

18.3 Energy

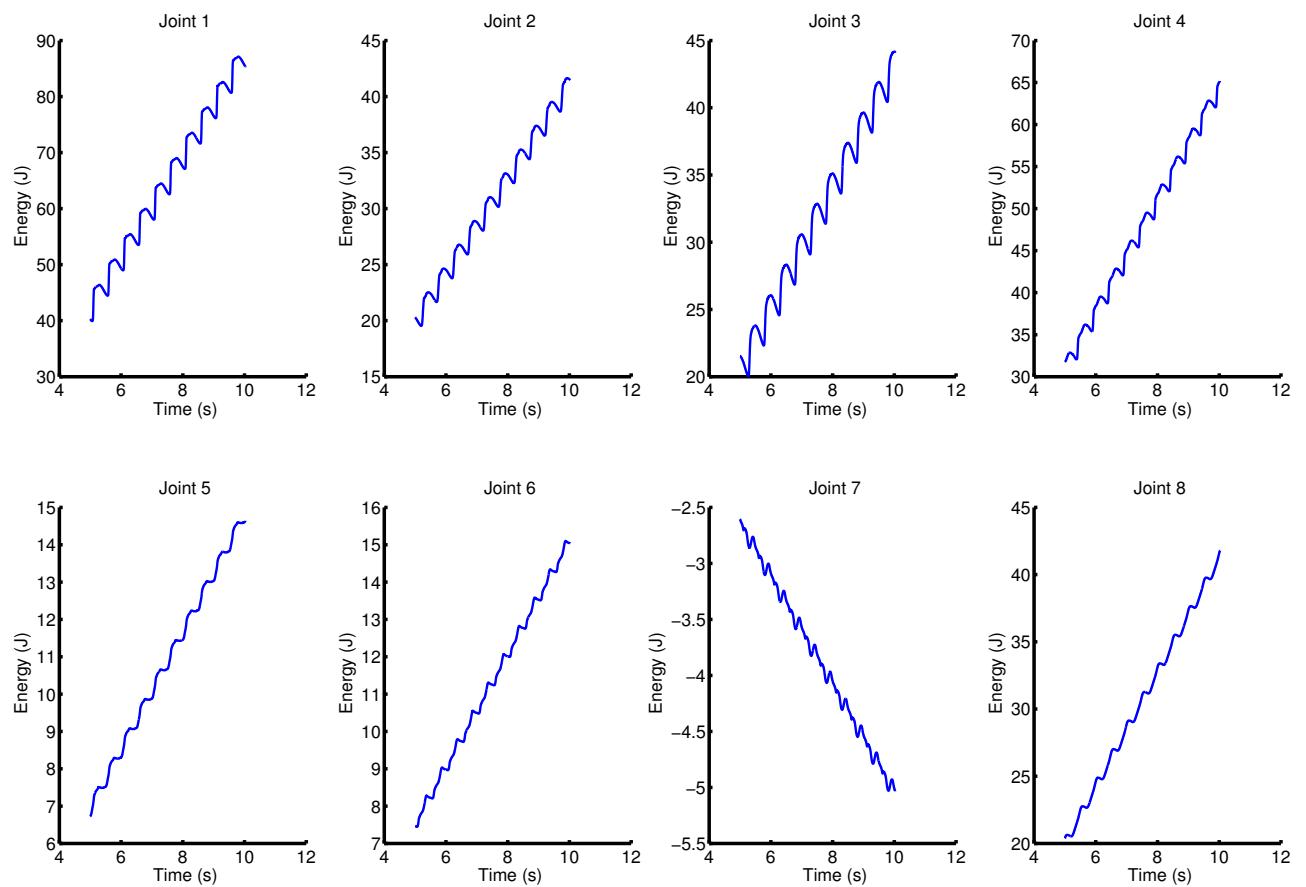


Figure 18.7: Energy_Opti_9seg_tail_w62_shaped_Full_1Hz_4

19 Opti_9seg_tail_w62_shaped_Full_1Hz_5

19.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_5/Opti_9seg_tail_w62_shaped_Full_1Hz_5.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	27.628	14.282	29.861	75.941	102.211	98.969	110.150	106.198
Lopt (m)	0.070	0.071	0.088	0.088	0.112	0.090	0.139	0.110
r (m)	0.133	0.062	0.125	0.135	0.136	0.040	0.131	0.135
TimeLag (s)	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
error	0.153	0.153	0.153	0.153	0.153	0.153	0.153	0.153
Fitness	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523

Table 19.1: Optimised Parameters

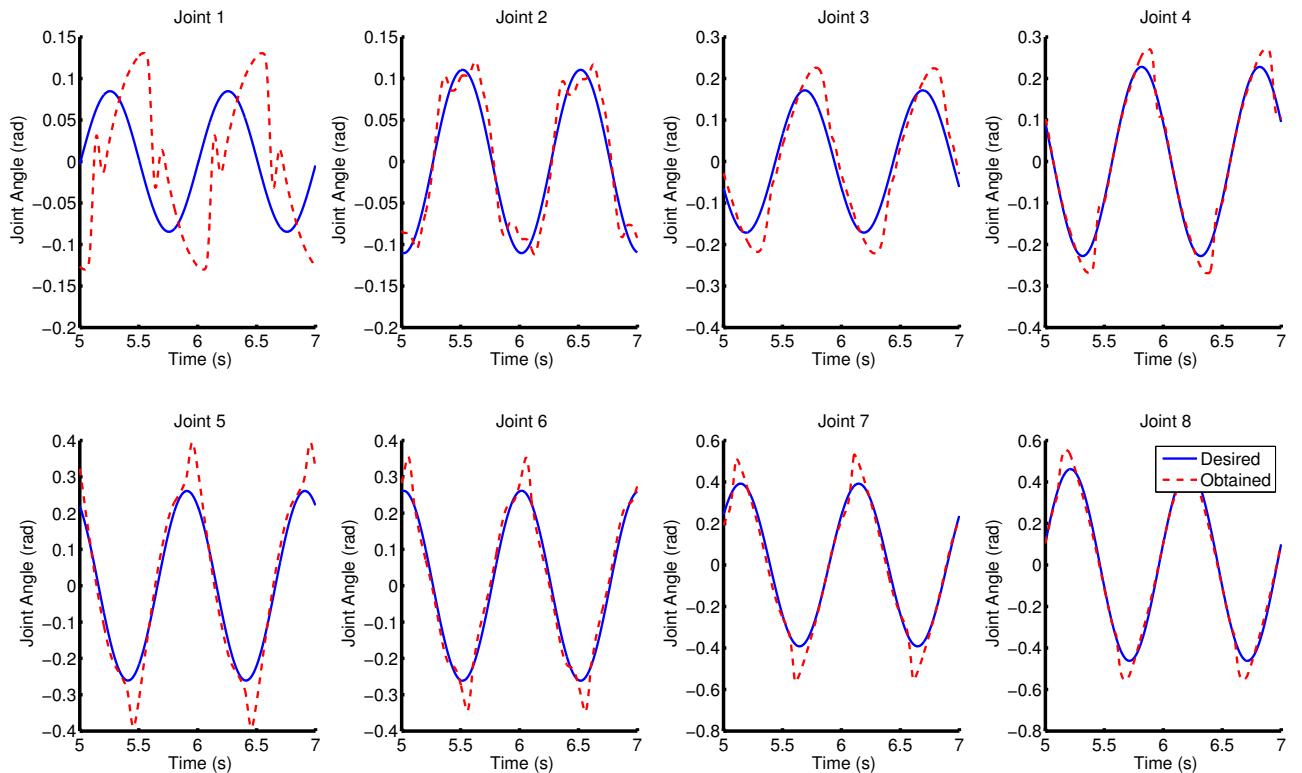


Figure 19.1: AngleDiff_Opti_9seg_tail_w62_shaped_Full_1Hz_5

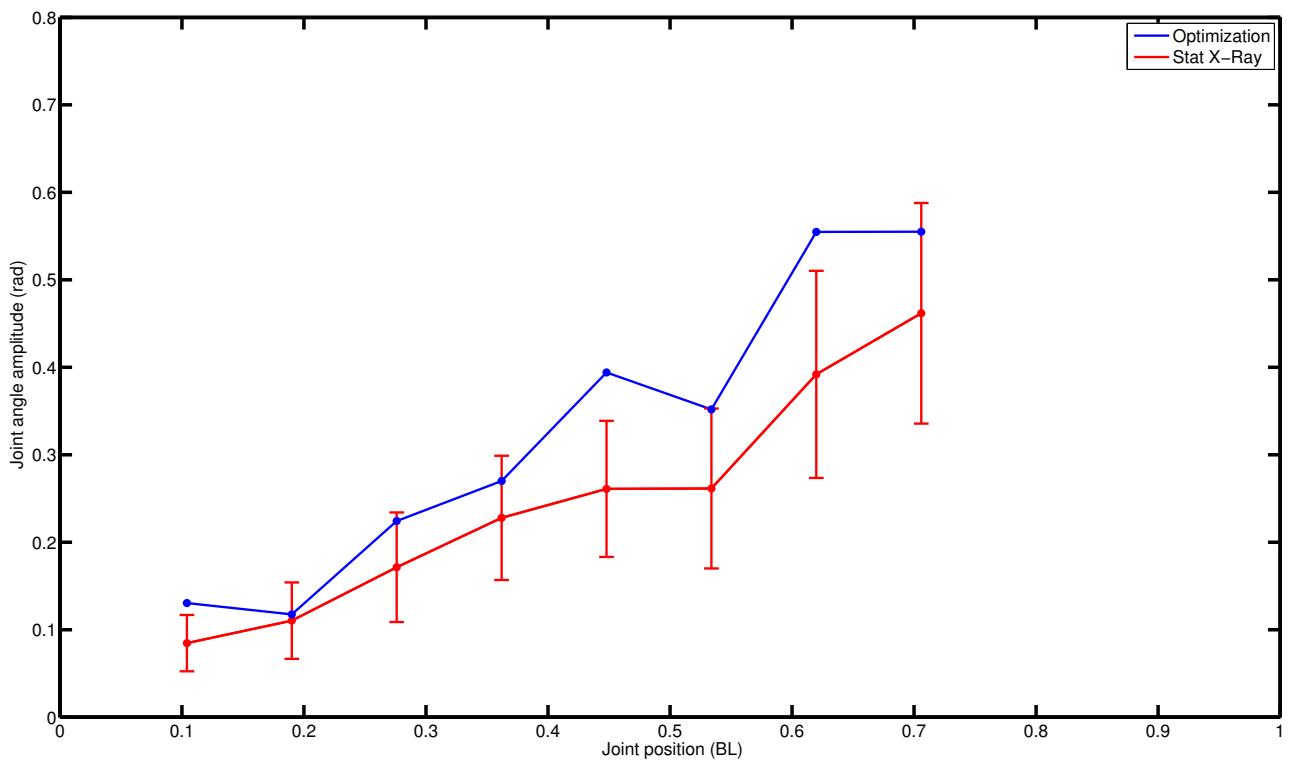


Figure 19.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Full_1Hz_5

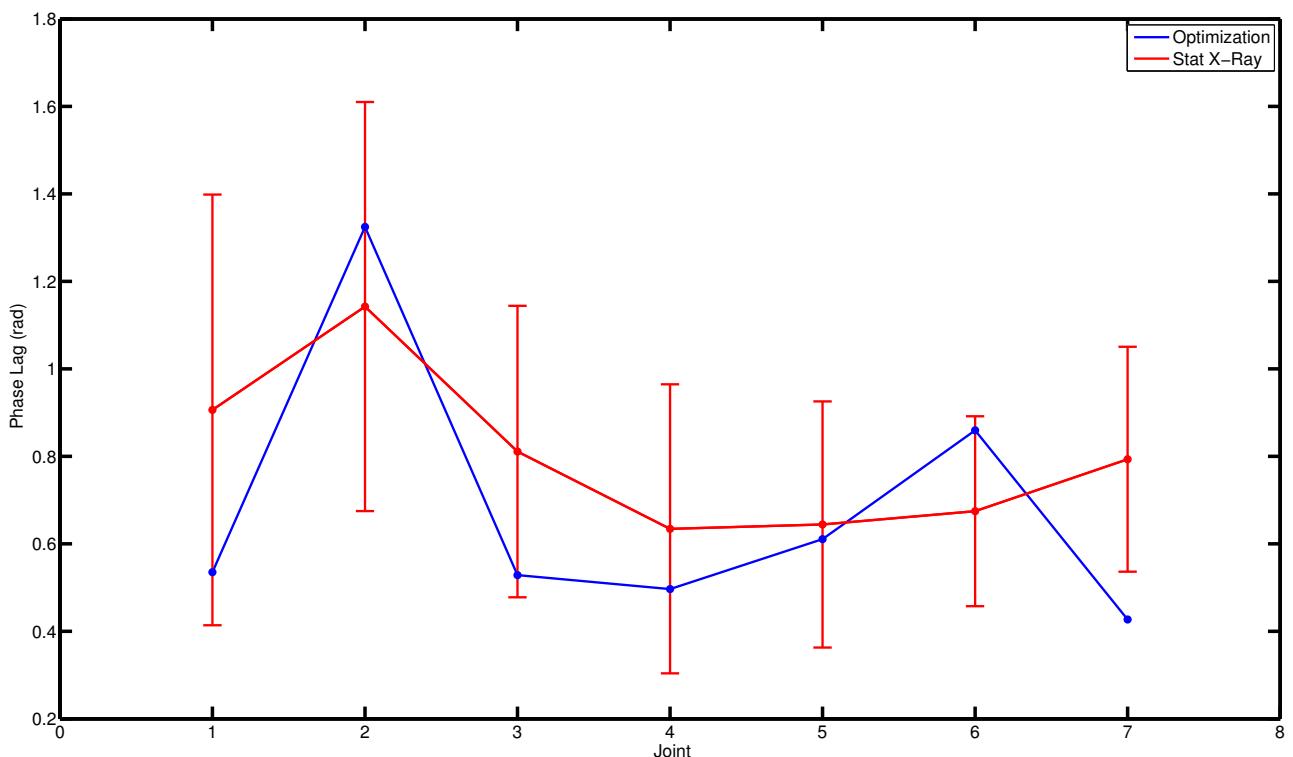


Figure 19.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Full_1Hz_5

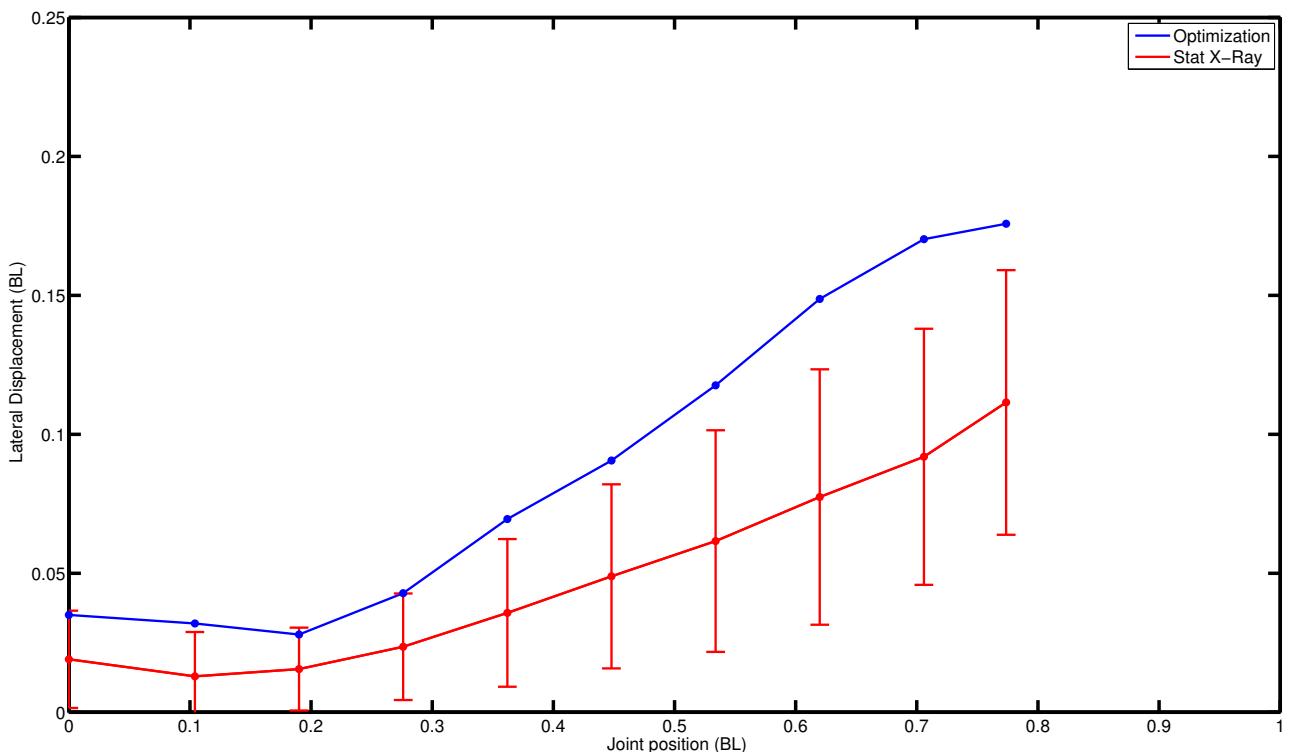


Figure 19.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Full_1Hz_5

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.035	NaN	NaN
Joint 1	0.032	0.130	NaN
Joint 2	0.028	0.118	0.535
Joint 3	0.043	0.224	1.324
Joint 4	0.070	0.270	0.528
Joint 5	0.091	0.394	0.497
Joint 6	0.118	0.352	0.611
Joint 7	0.149	0.555	0.859
Joint 8	0.170	0.555	0.427
Joint 9	0.176	NaN	NaN

Table 19.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.544	1.079	1.982

Table 19.3: Speed data

19.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Full_1Hz_5/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_5.mp4

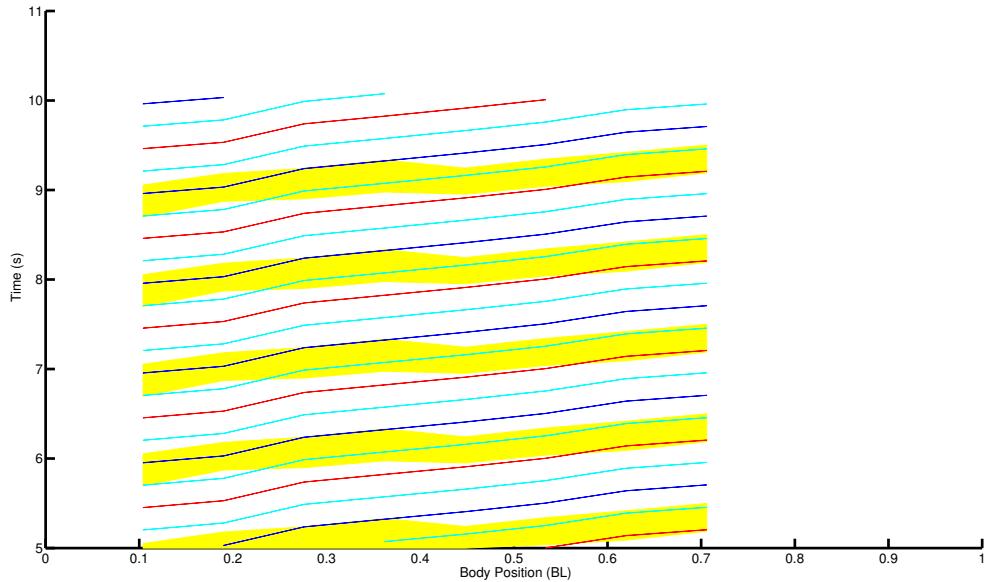


Figure 19.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Full_1Hz_5

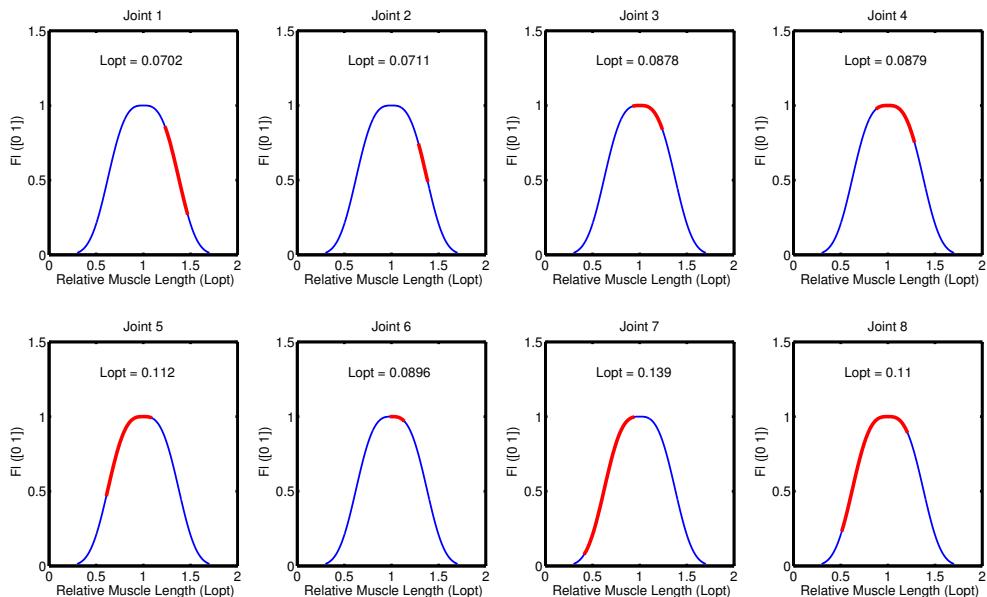


Figure 19.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Full_1Hz_5

19.3 Energy

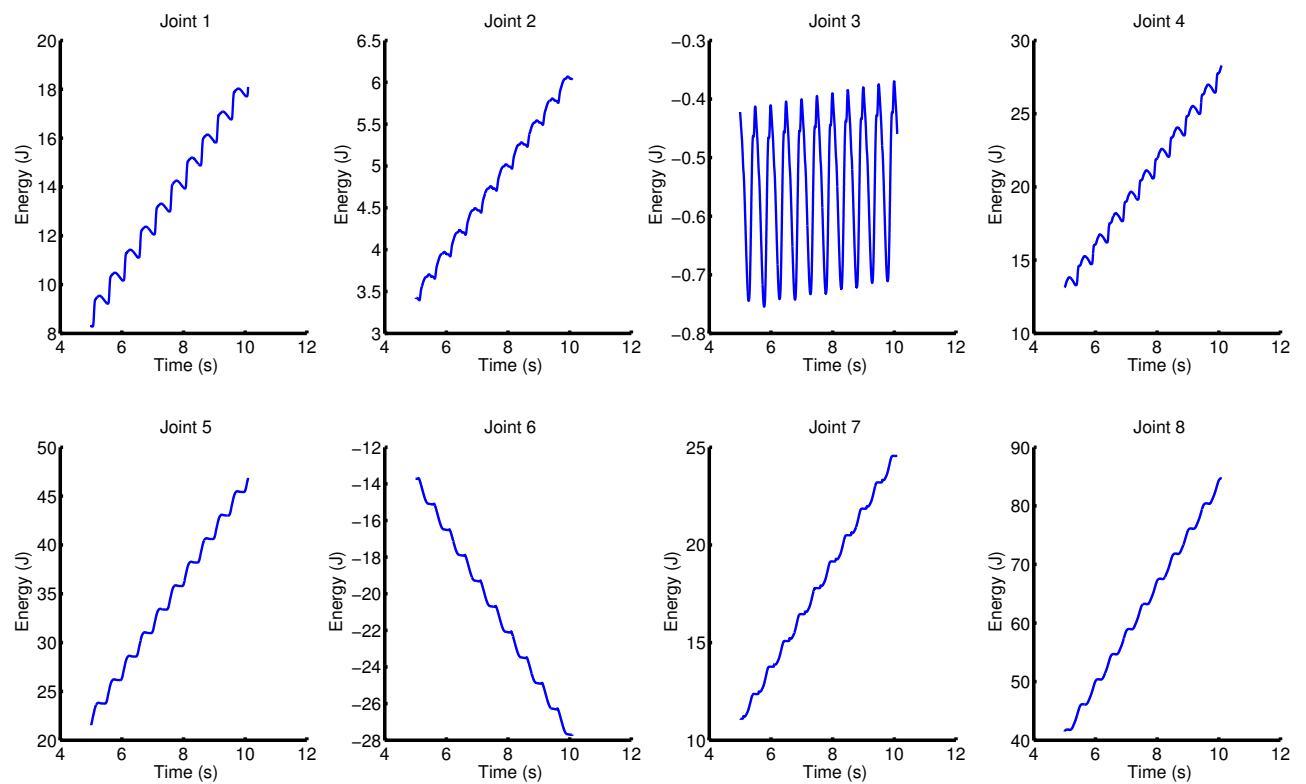


Figure 19.7: Energy_Opti_9seg_tail_w62_shaped_Full_1Hz_5

20 Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

20.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1/Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	30.510	28.163	139.223	129.725	115.875	98.360	82.520	18.331
Lopt (m)	0.091	0.141	0.091	0.091	0.091	0.143	0.089	0.113
r (m)	0.136	0.082	0.136	0.073	0.028	0.115	0.078	0.015
TimeLag (s)	0.584	0.584	0.584	0.584	0.584	0.584	0.584	0.584
error	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
Fitness	1.594	1.594	1.594	1.594	1.594	1.594	1.594	1.594

Table 20.1: Optimised Parameters

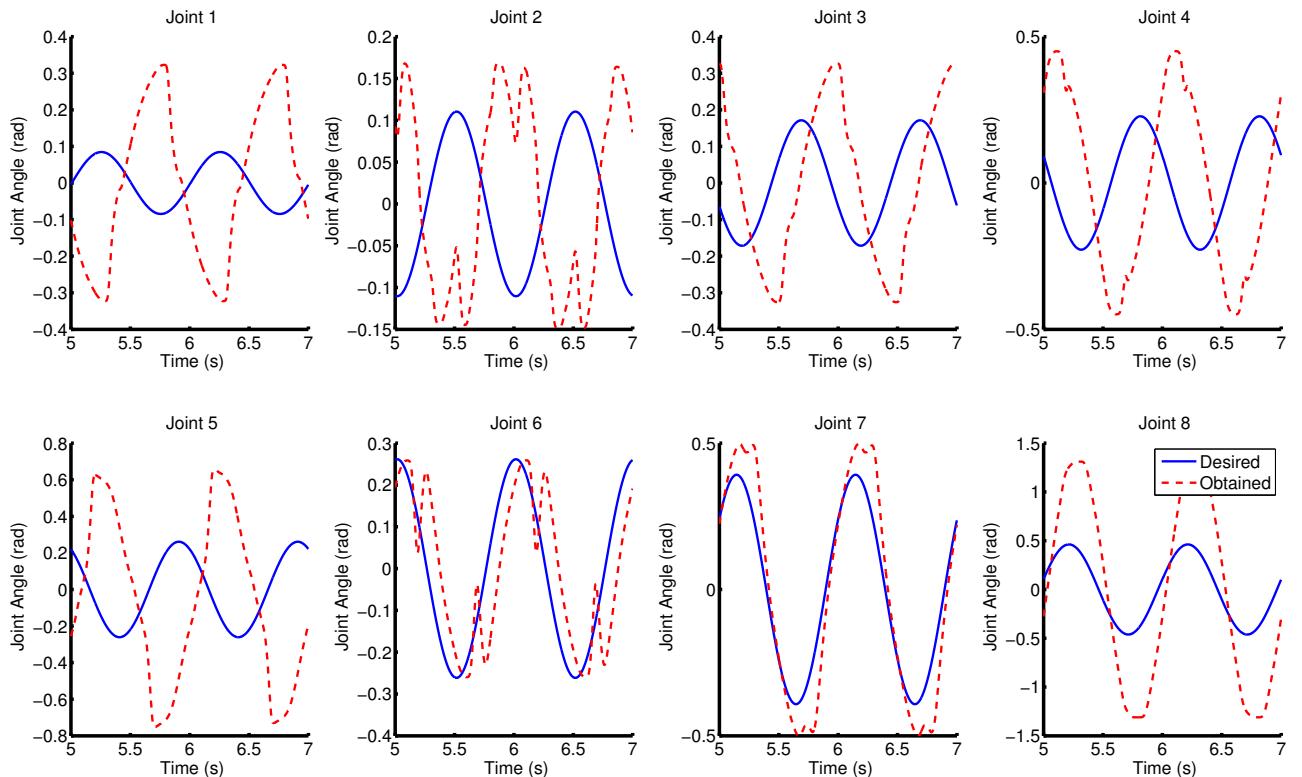


Figure 20.1: AngleDiff_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

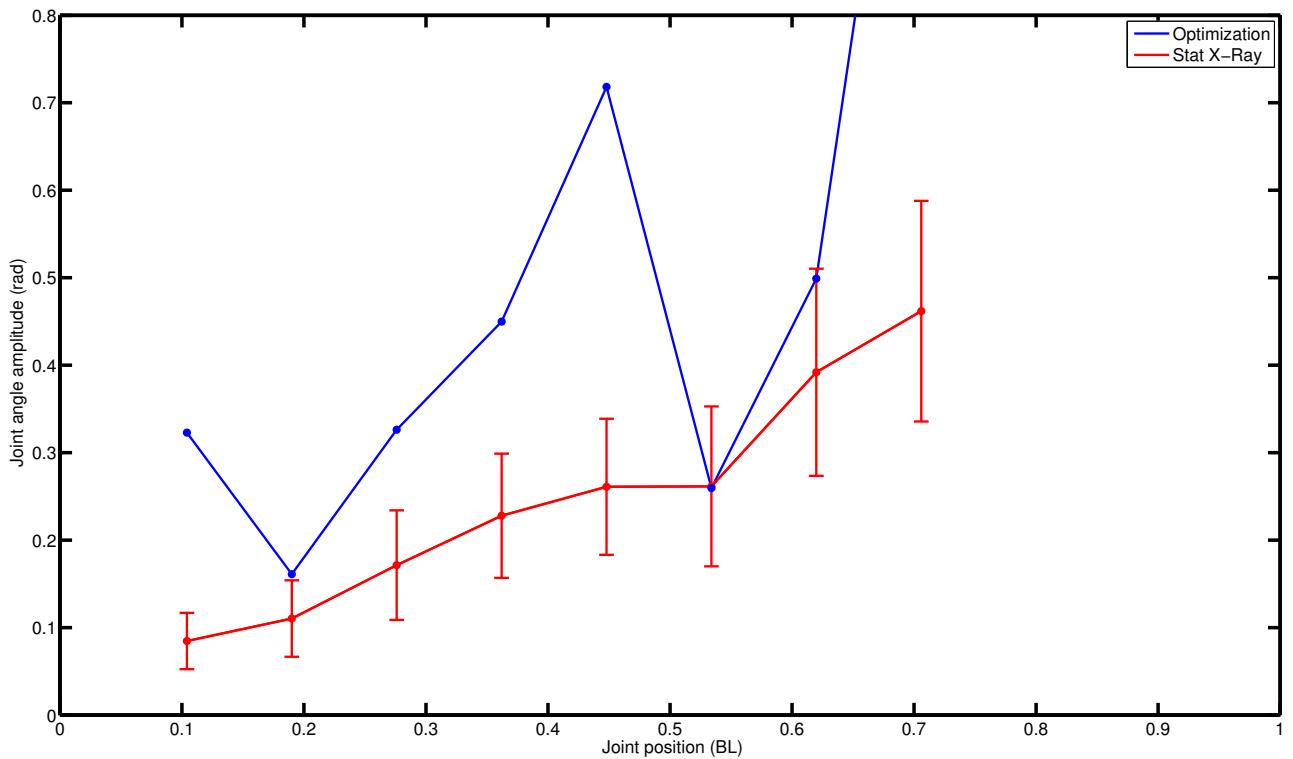


Figure 20.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

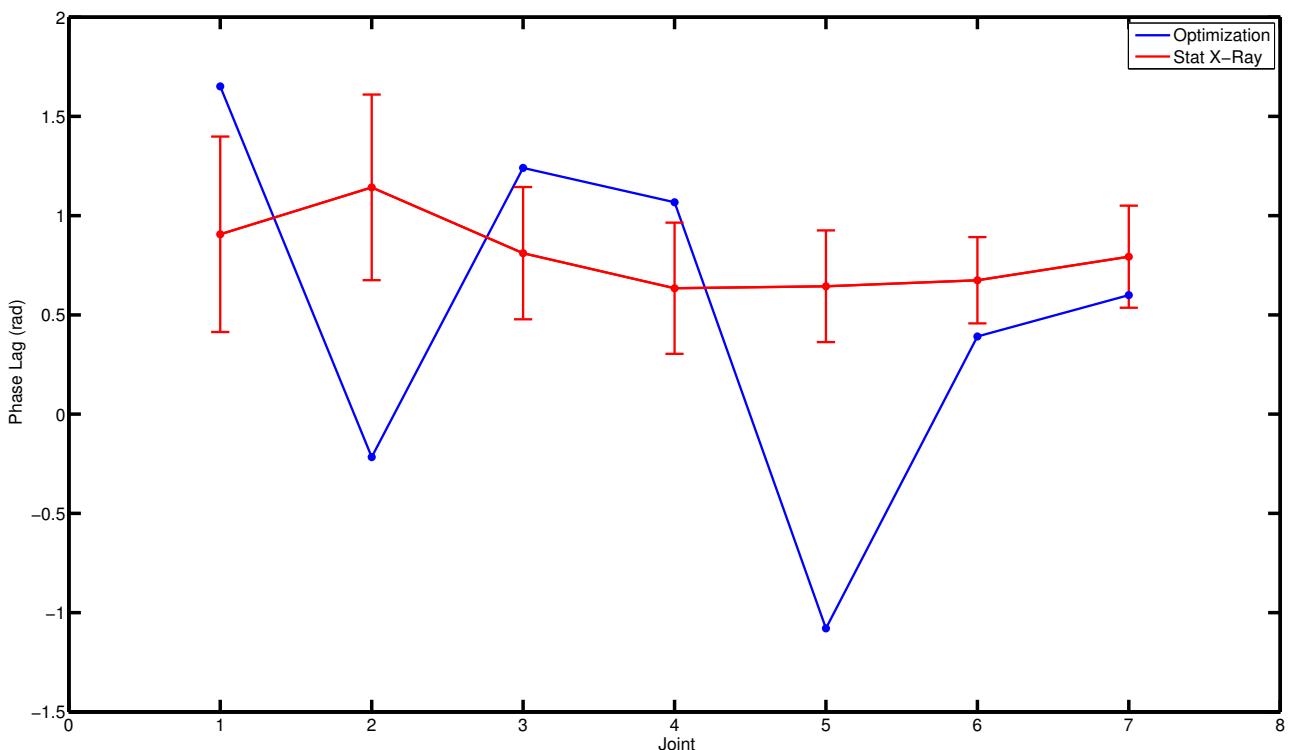


Figure 20.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

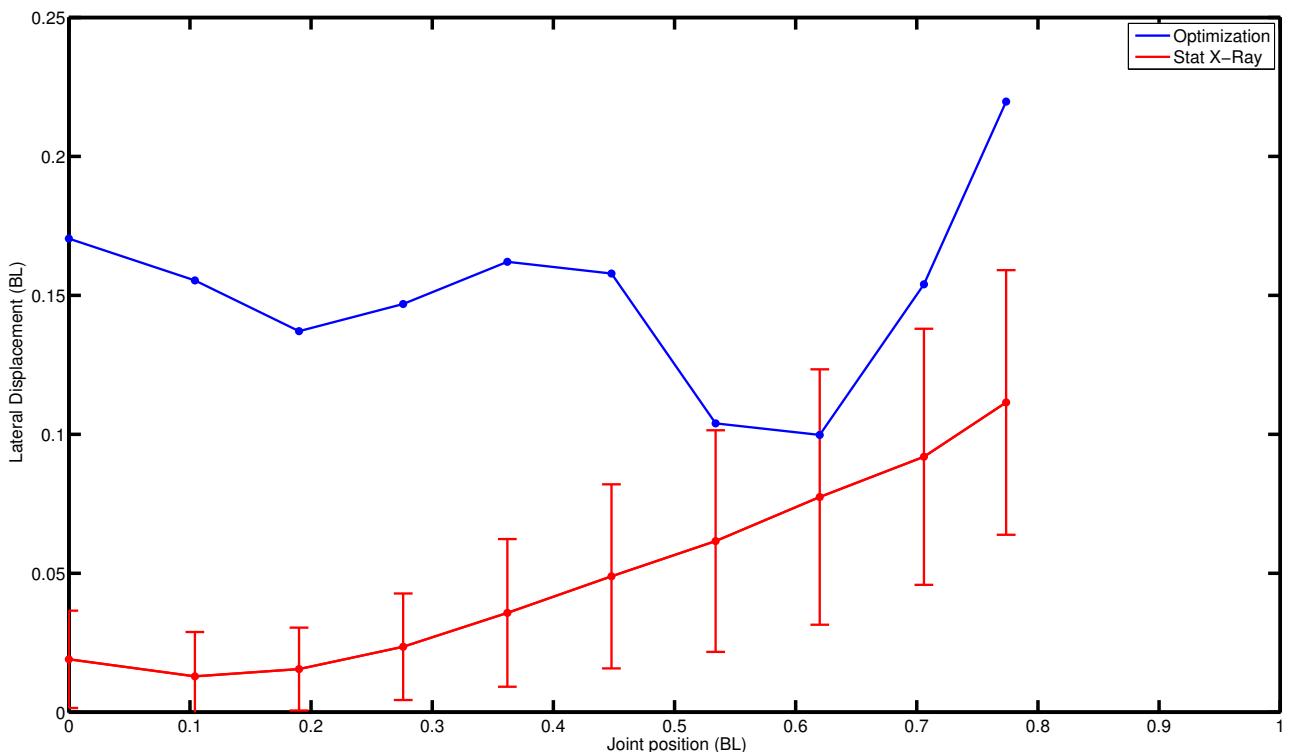


Figure 20.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.170	NaN	NaN
Joint 1	0.155	0.323	NaN
Joint 2	0.137	0.161	1.651
Joint 3	0.147	0.326	-0.217
Joint 4	0.162	0.450	1.241
Joint 5	0.158	0.718	1.068
Joint 6	0.104	0.260	-1.079
Joint 7	0.100	0.499	0.391
Joint 8	0.154	1.310	0.600
Joint 9	0.220	NaN	NaN

Table 20.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.294	1.818	6.193

Table 20.3: Speed data

20.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1.mp4

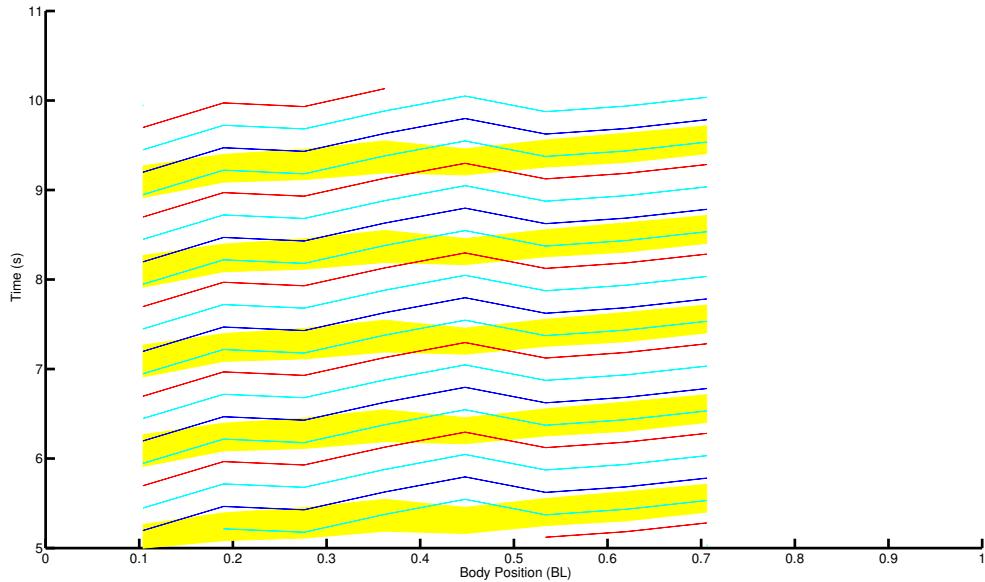


Figure 20.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

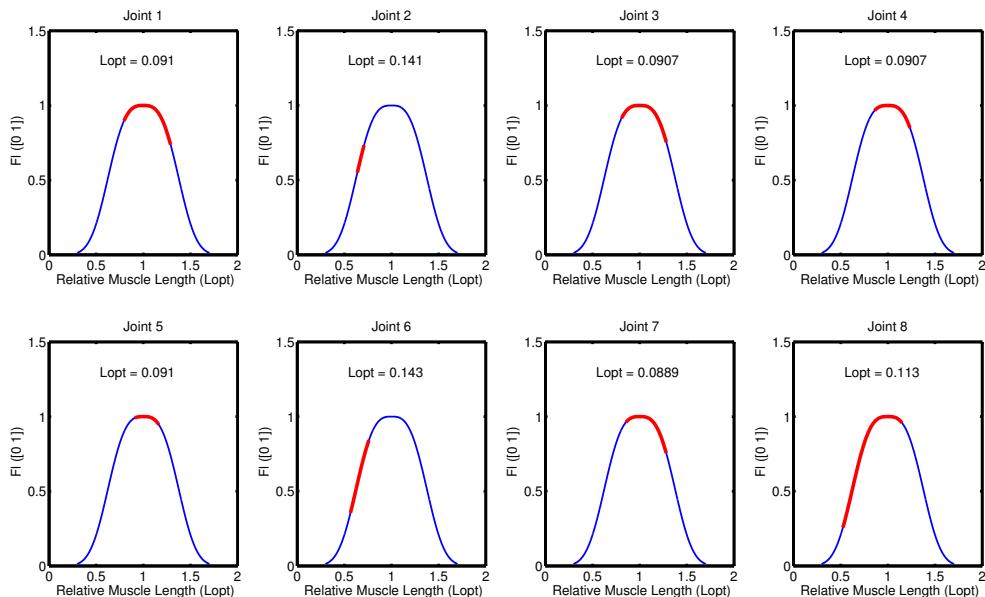


Figure 20.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

20.3 Energy

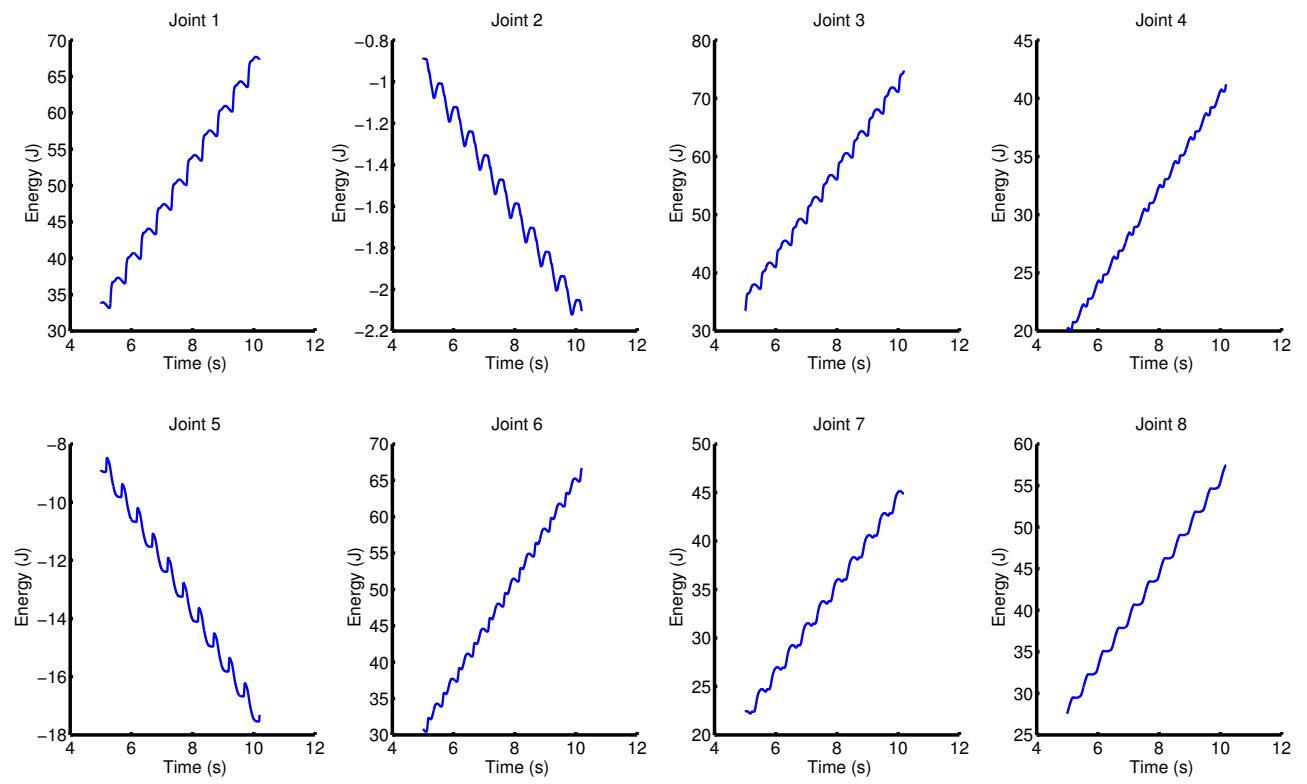


Figure 20.7: Energy_Opti_9seg_notail_w62_Full_Lopt_restrain_1Hz_1

21 Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

21.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1/Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	25.436	5.999	31.572	109.878	113.651	90.690	82.789	59.361
Lopt (m)	0.083	0.084	0.085	0.086	0.108	0.099	0.103	0.101
r (m)	0.139	0.125	0.129	0.131	0.130	0.135	0.133	0.133
TimeLag (s)	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775
error	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
Fitness	5.060	5.060	5.060	5.060	5.060	5.060	5.060	5.060

Table 21.1: Optimised Parameters

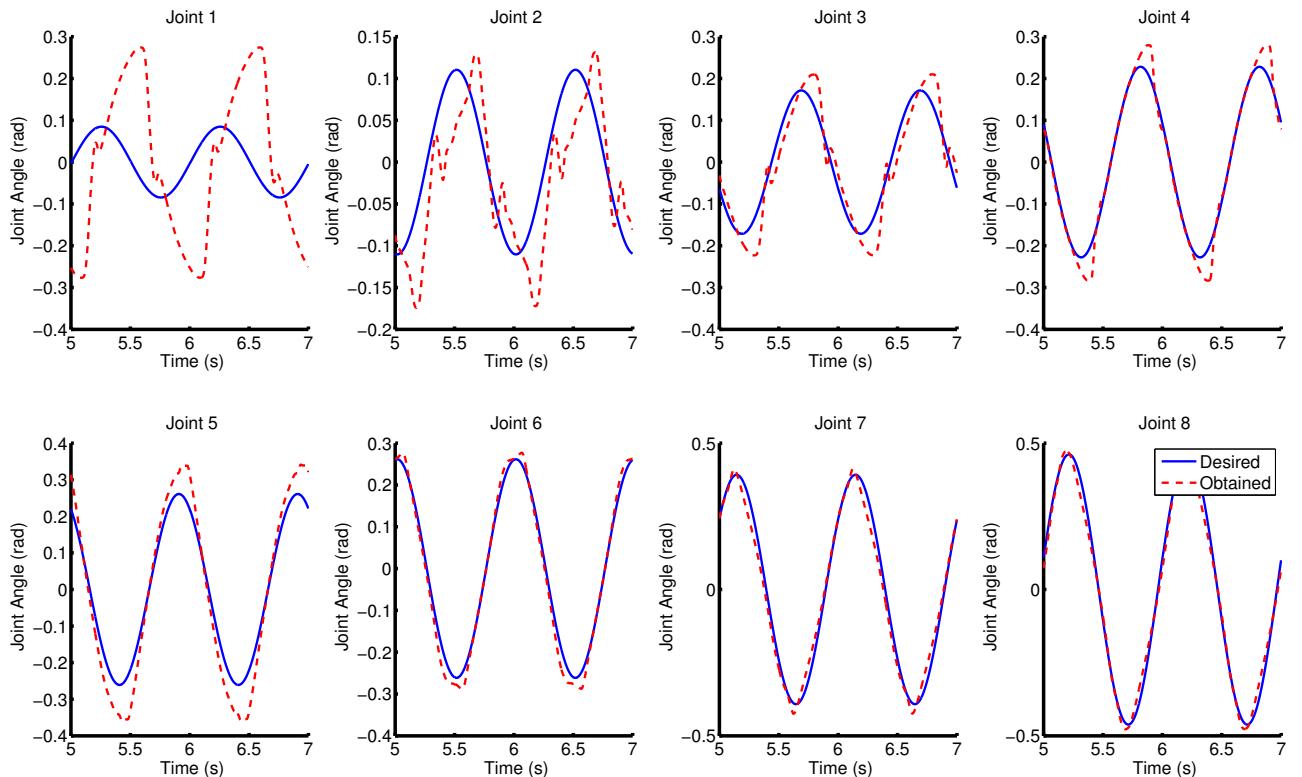


Figure 21.1: AngleDiff_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

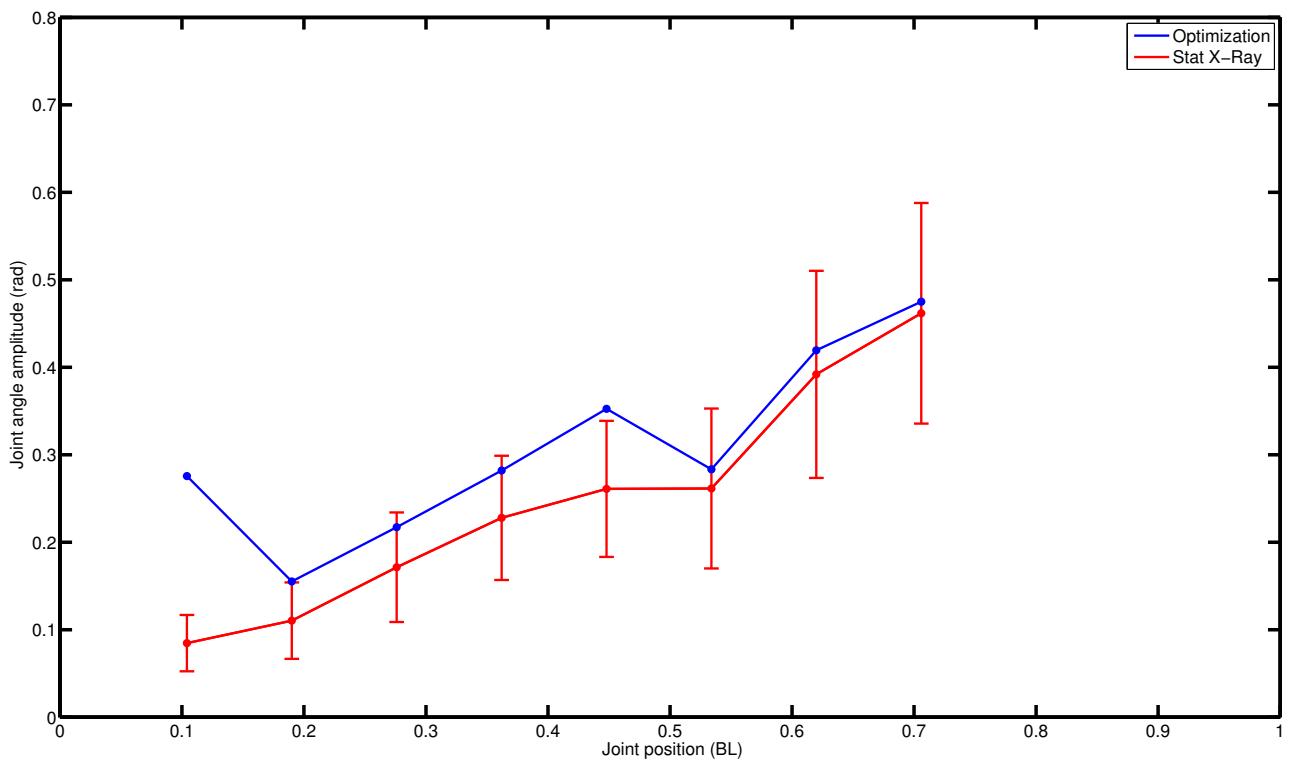


Figure 21.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

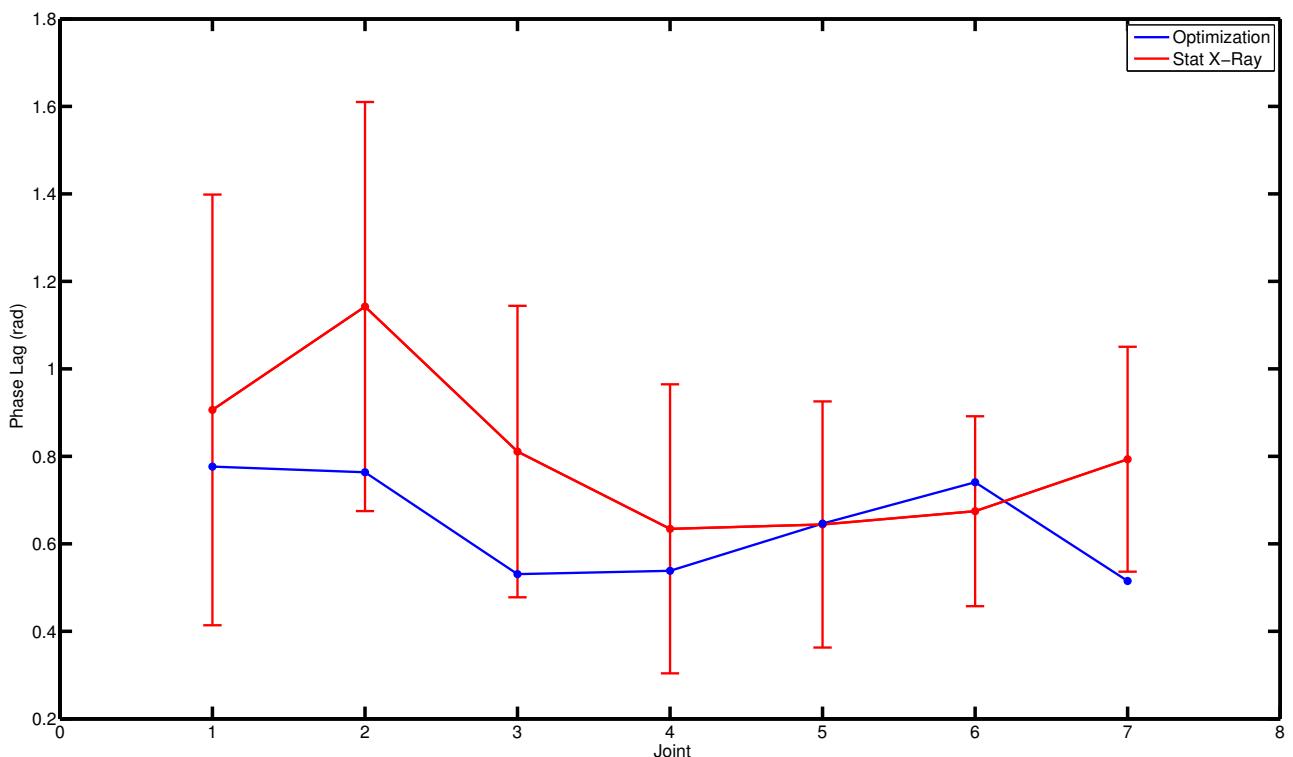


Figure 21.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

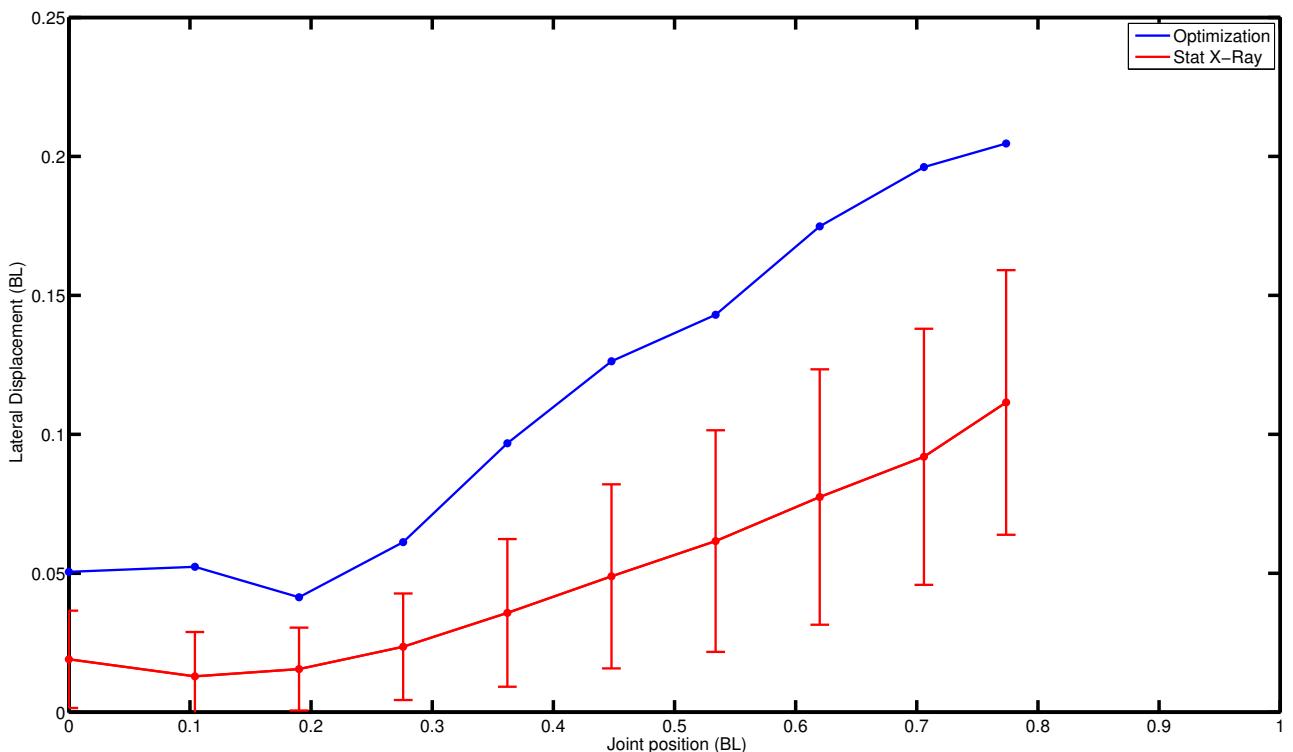


Figure 21.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.051	NaN	NaN
Joint 1	0.052	0.276	NaN
Joint 2	0.041	0.155	0.777
Joint 3	0.061	0.217	0.764
Joint 4	0.097	0.282	0.531
Joint 5	0.126	0.353	0.538
Joint 6	0.143	0.283	0.646
Joint 7	0.175	0.419	0.741
Joint 8	0.196	0.475	0.515
Joint 9	0.205	NaN	NaN

Table 21.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.599	0.978	1.634

Table 21.3: Speed data

21.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1.mp4

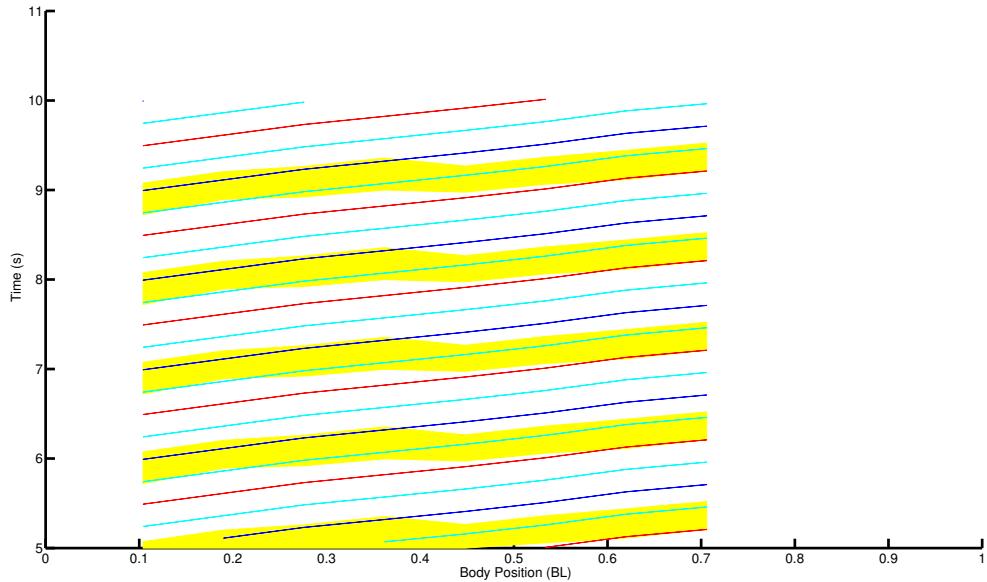


Figure 21.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

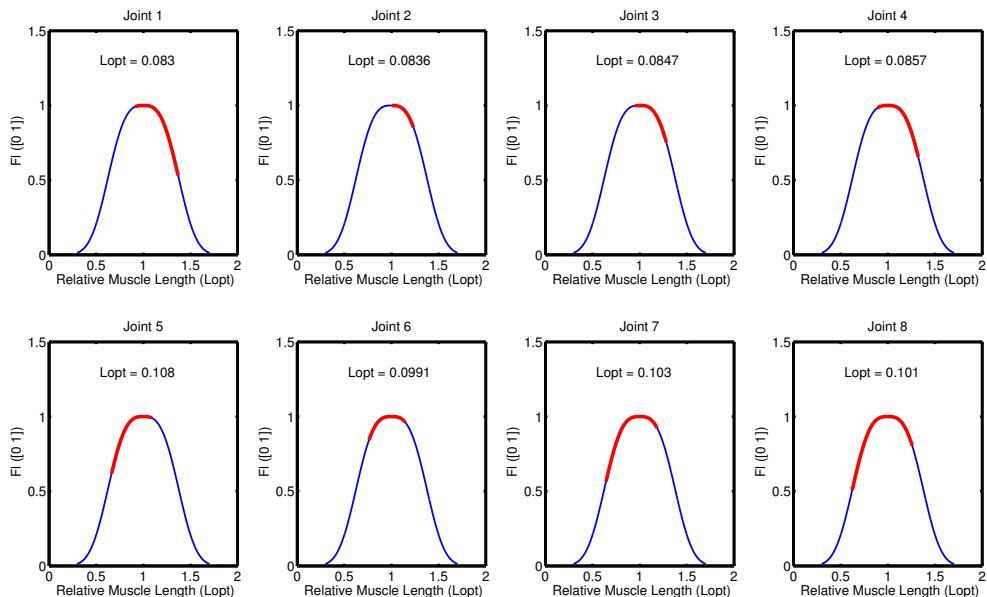


Figure 21.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

21.3 Energy

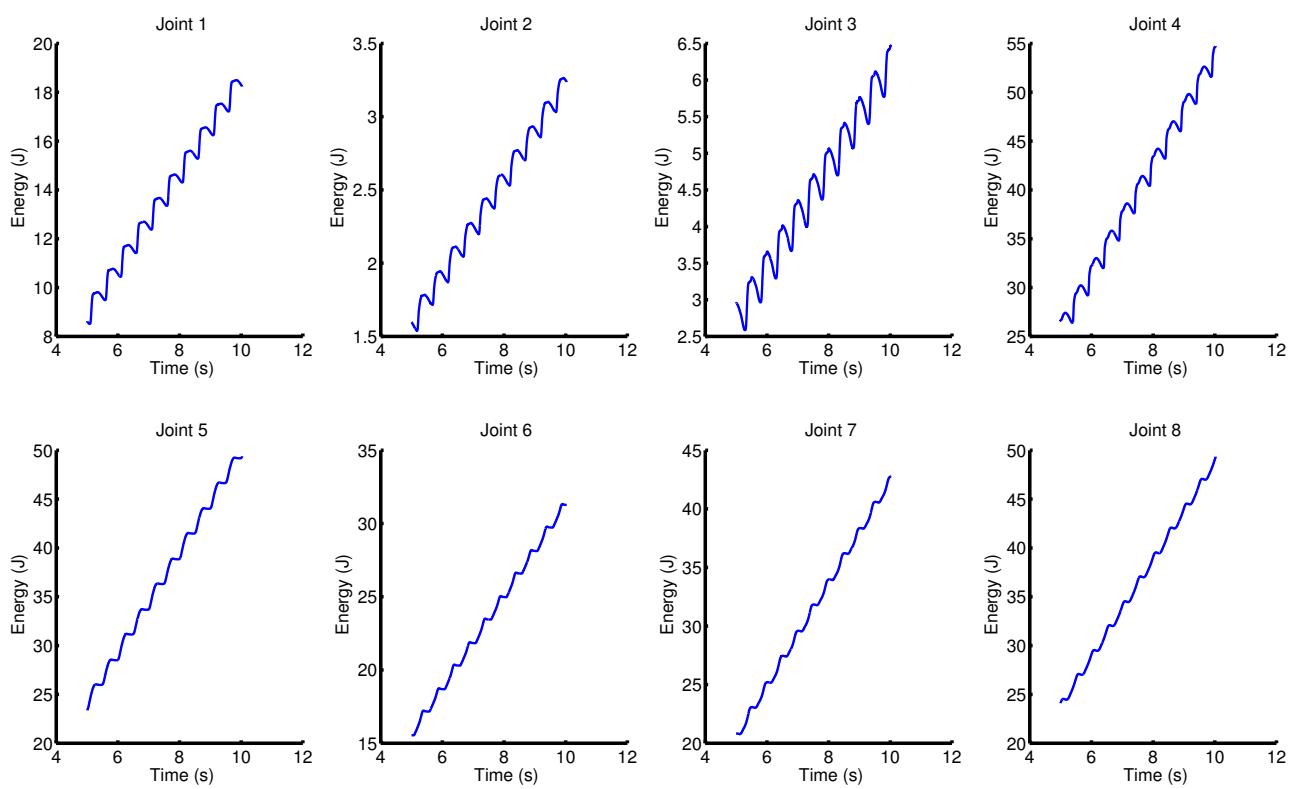


Figure 21.7: Energy_Opti_9seg_tail_w62_Full_Lopt_restrain_1Hz_1

22 Opti_9seg_notail_w62_Profile_1Hz_1

22.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Profile_1Hz_1/Opti_9seg_notail_w62_Profile_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	13.175	14.559	13.815	10.336	6.090	3.575	1.959	0.968
Lopt (m)	0.070	0.071	0.095	0.085	0.074	0.097	0.074	0.071
r (m)	0.112	0.135	0.139	0.111	0.068	0.060	0.054	0.046
TimeLag (s)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
error	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220
Fitness	4.545	4.545	4.545	4.545	4.545	4.545	4.545	4.545

Table 22.1: Optimised Parameters

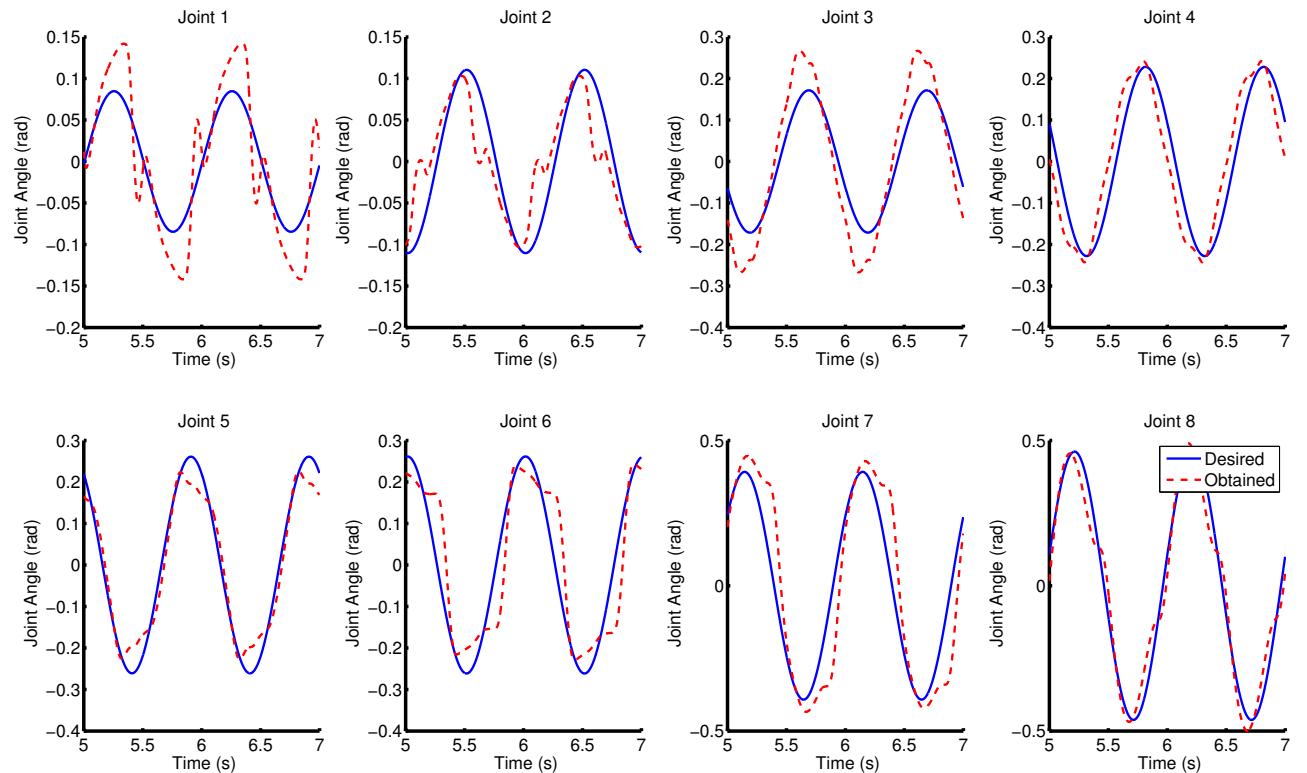


Figure 22.1: AngleDiff_Opti_9seg_notail_w62_Profile_1Hz_1

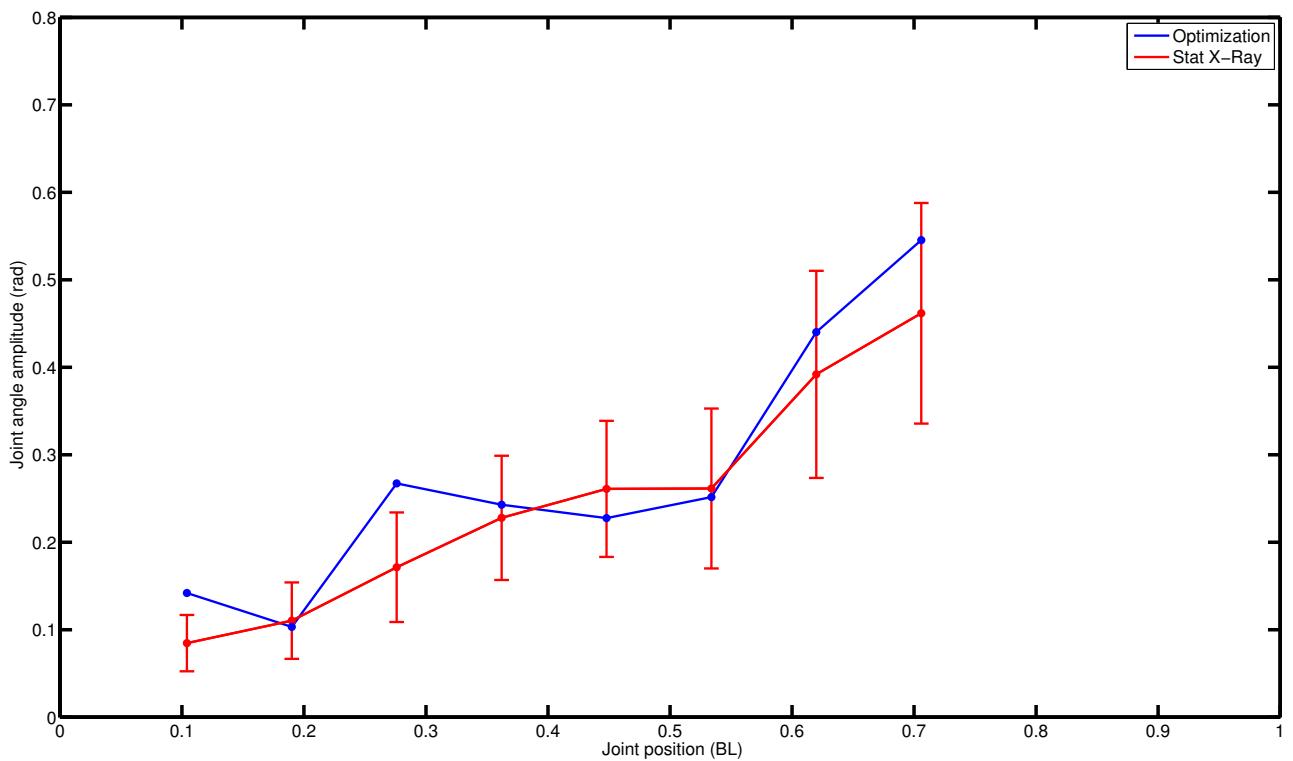


Figure 22.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Profile_1Hz_1

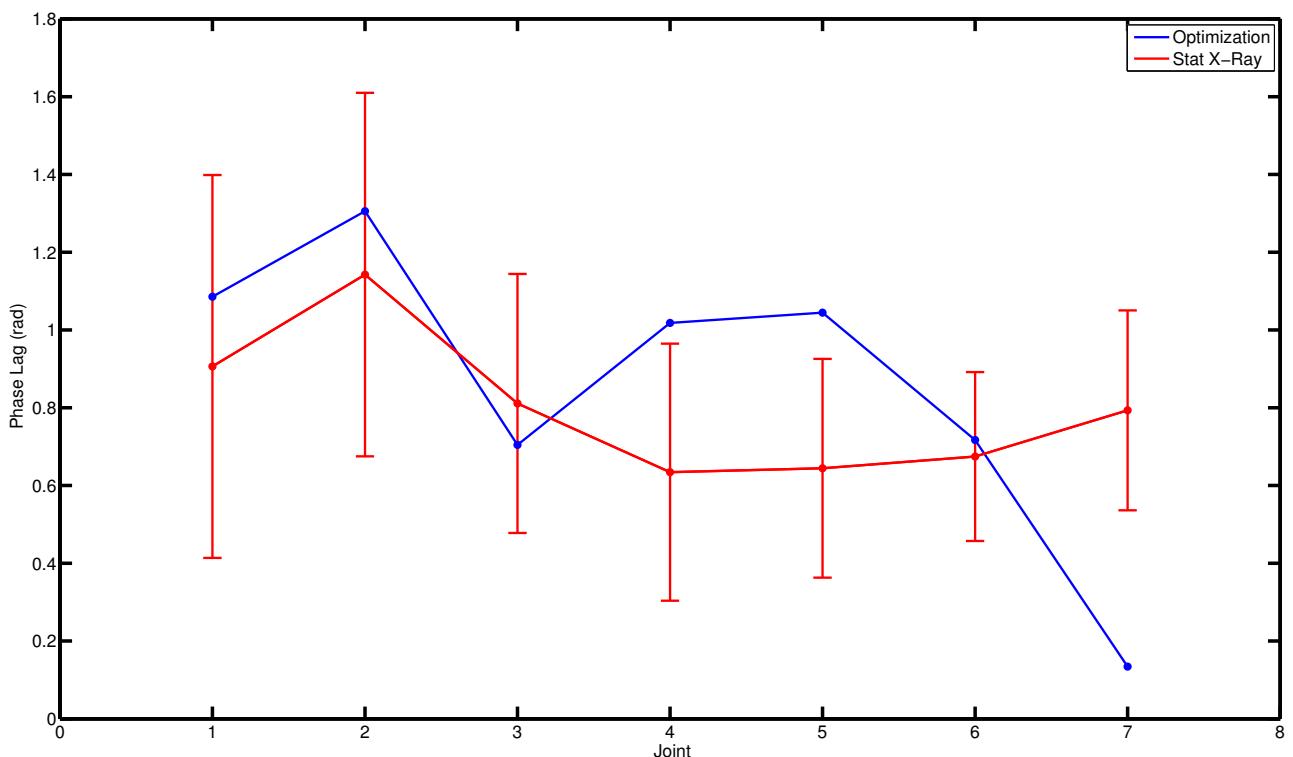


Figure 22.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Profile_1Hz_1

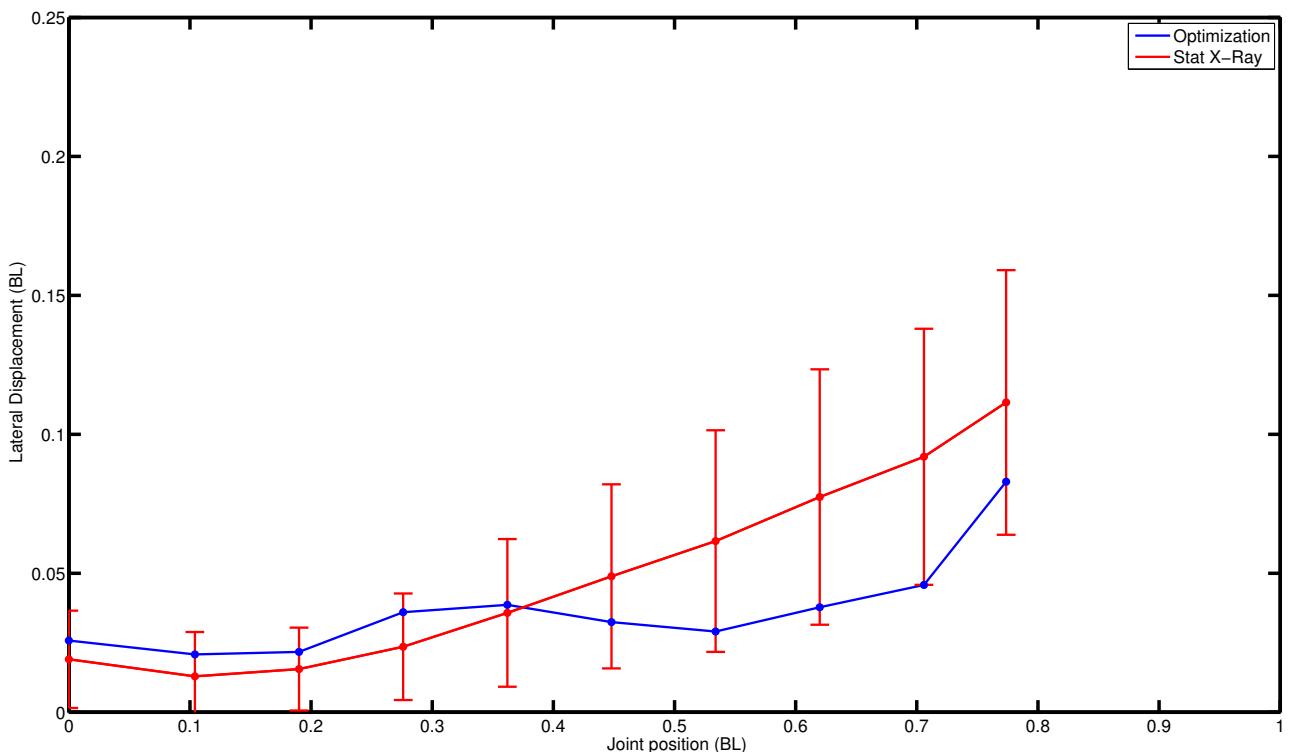


Figure 22.4: LateralDisplacementComp_Opti_9seg_notail_w62_Profile_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.026	NaN	NaN
Joint 1	0.021	0.142	NaN
Joint 2	0.022	0.103	1.086
Joint 3	0.036	0.267	1.305
Joint 4	0.039	0.243	0.704
Joint 5	0.032	0.228	1.018
Joint 6	0.029	0.252	1.045
Joint 7	0.038	0.440	0.717
Joint 8	0.046	0.545	0.134
Joint 9	0.083	NaN	NaN

Table 22.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.188	0.184	0.977

Table 22.3: Speed data

22.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Profile_1Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_Profile_1Hz_1.mp4

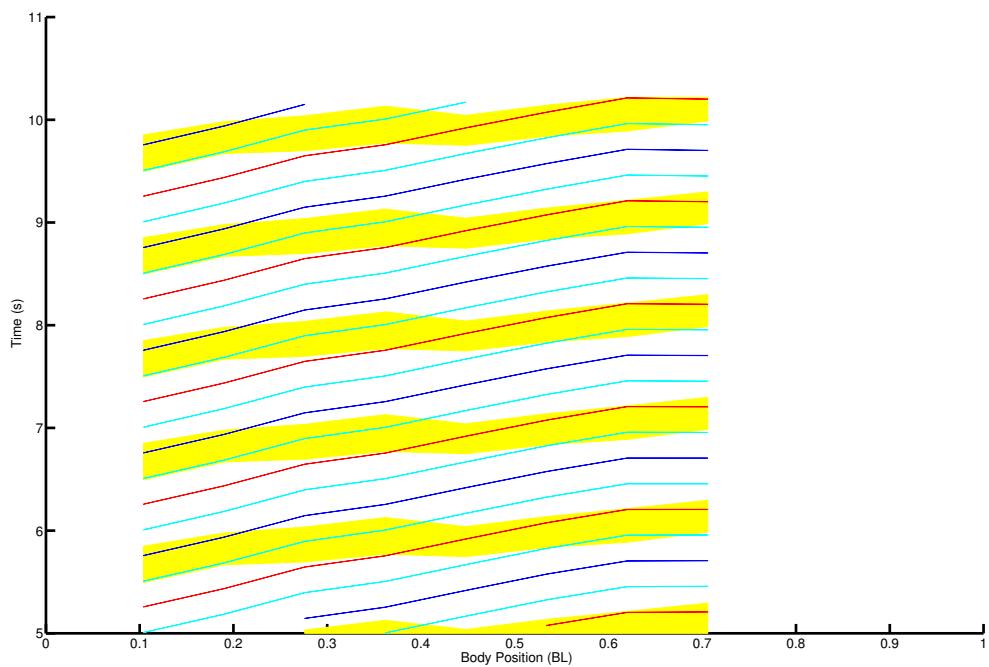


Figure 22.5: BodyMuscleActivity_Opti_9seg_notail_w62_Profile_1Hz_1

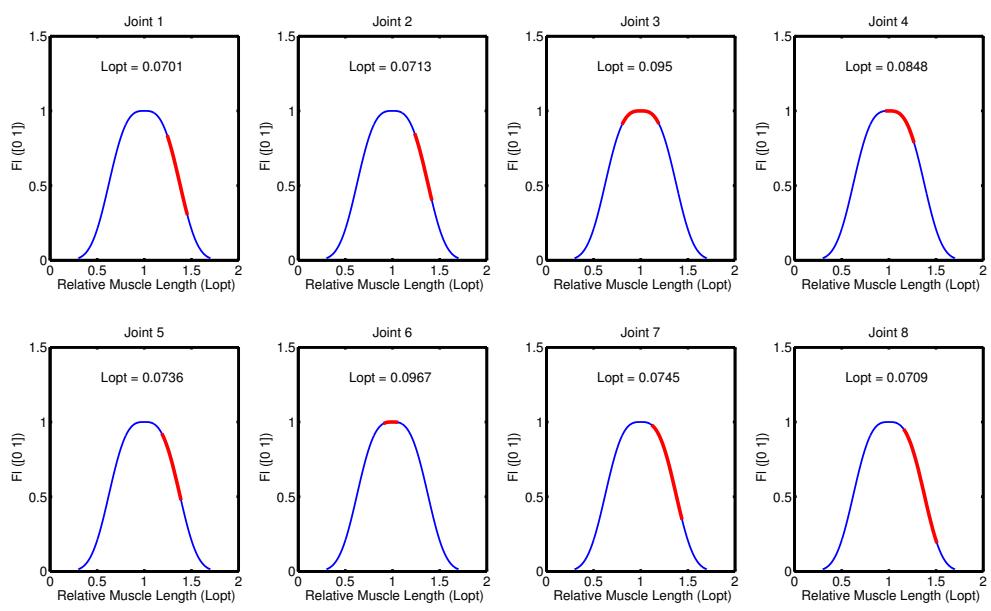


Figure 22.6: MuscleWorkingZone_Opti_9seg_notail_w62_Profile_1Hz_1

22.3 Energy

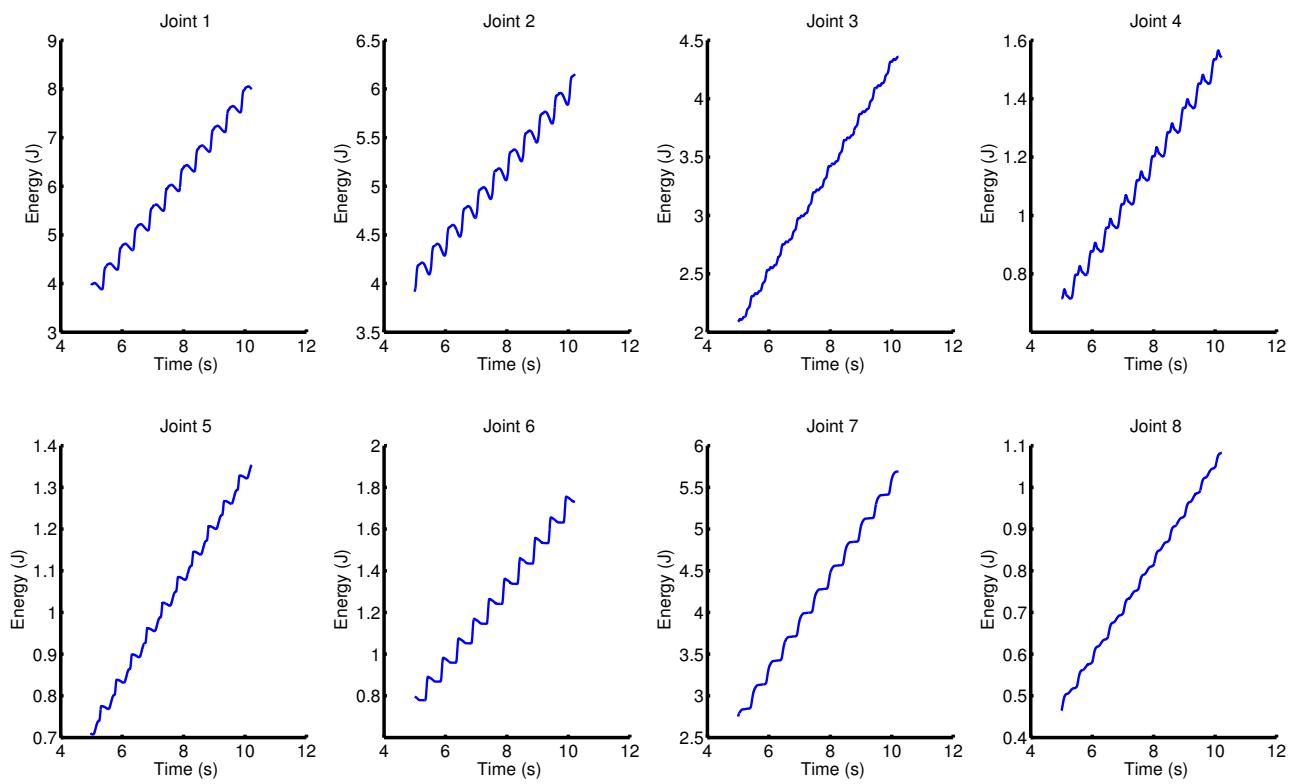


Figure 22.7: Energy_Opti_9seg_notail_w62_Profile_1Hz_1

23 Opti_9seg_tail_w62_Profile_1Hz_1

23.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Profile_1Hz_1/Opti_9seg_tail_w62_Profile_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	40.265	44.495	42.223	31.588	18.612	10.925	5.986	2.960
Lopt (m)	0.070	0.070	0.077	0.077	0.082	0.070	0.071	0.094
r (m)	0.112	0.135	0.139	0.111	0.068	0.060	0.054	0.046
TimeLag (s)	0.848	0.848	0.848	0.848	0.848	0.848	0.848	0.848
error	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
Fitness	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832

Table 23.1: Optimised Parameters

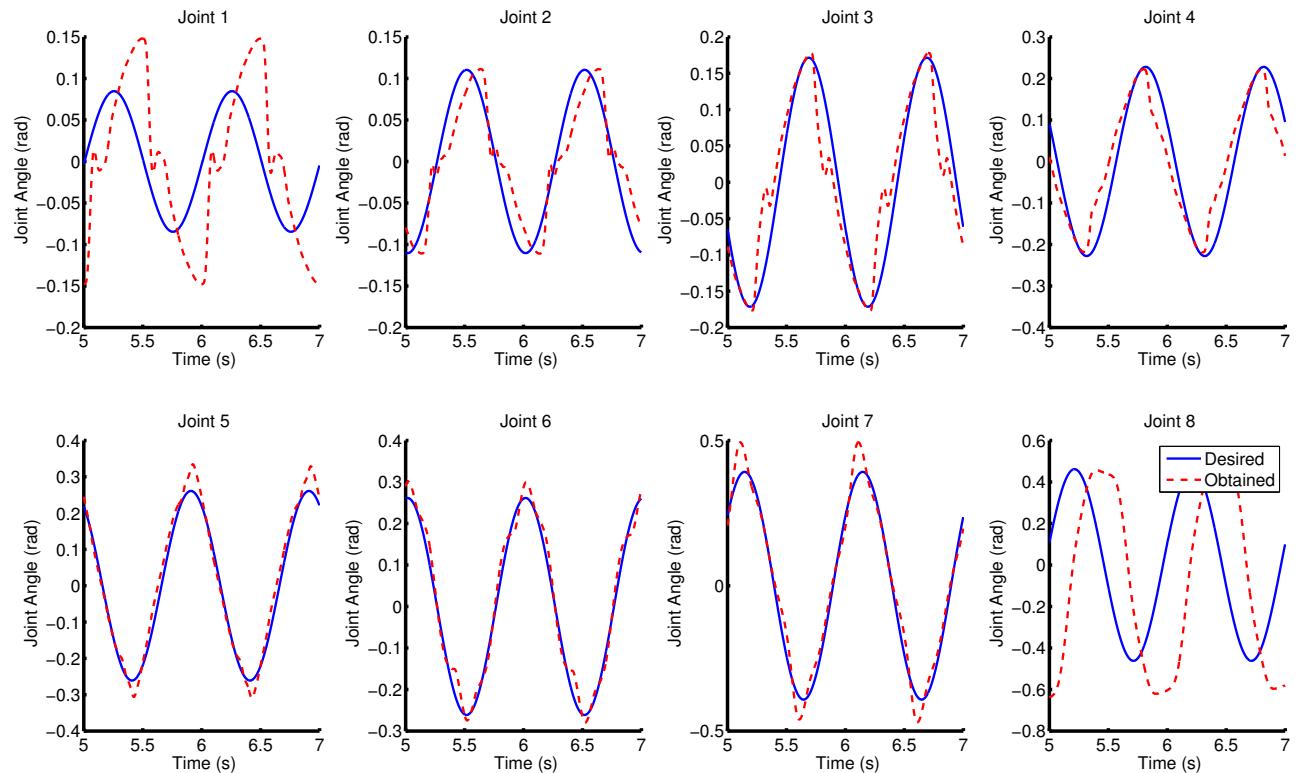


Figure 23.1: AngleDiff_Opti_9seg_tail_w62_Profile_1Hz_1

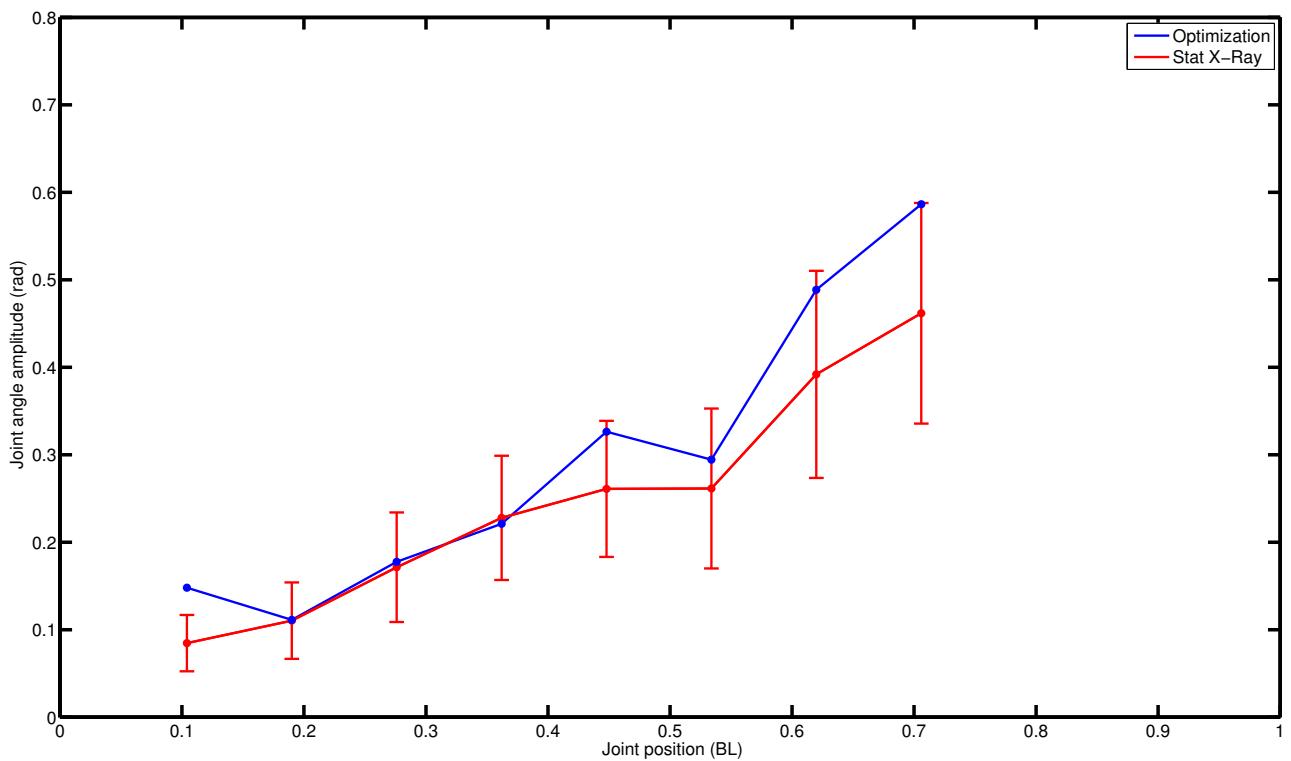


Figure 23.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Profile_1Hz_1

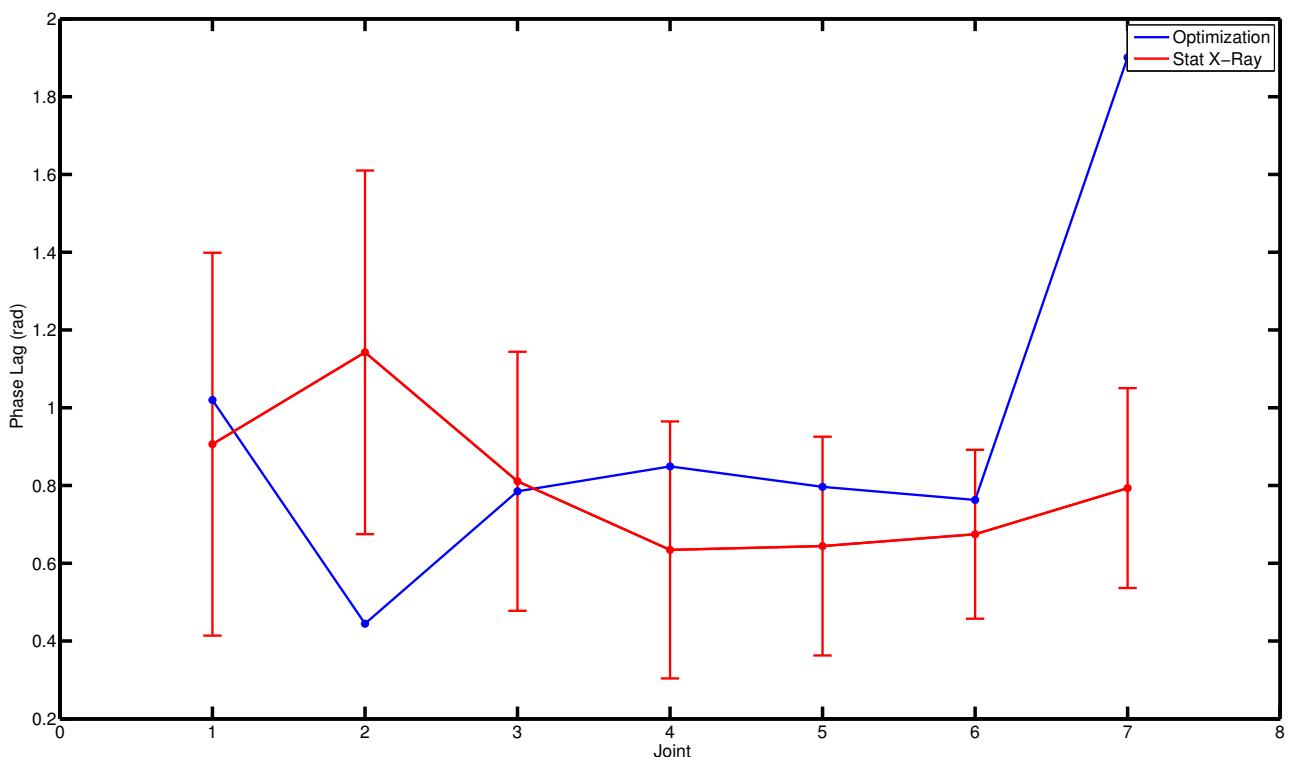


Figure 23.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Profile_1Hz_1

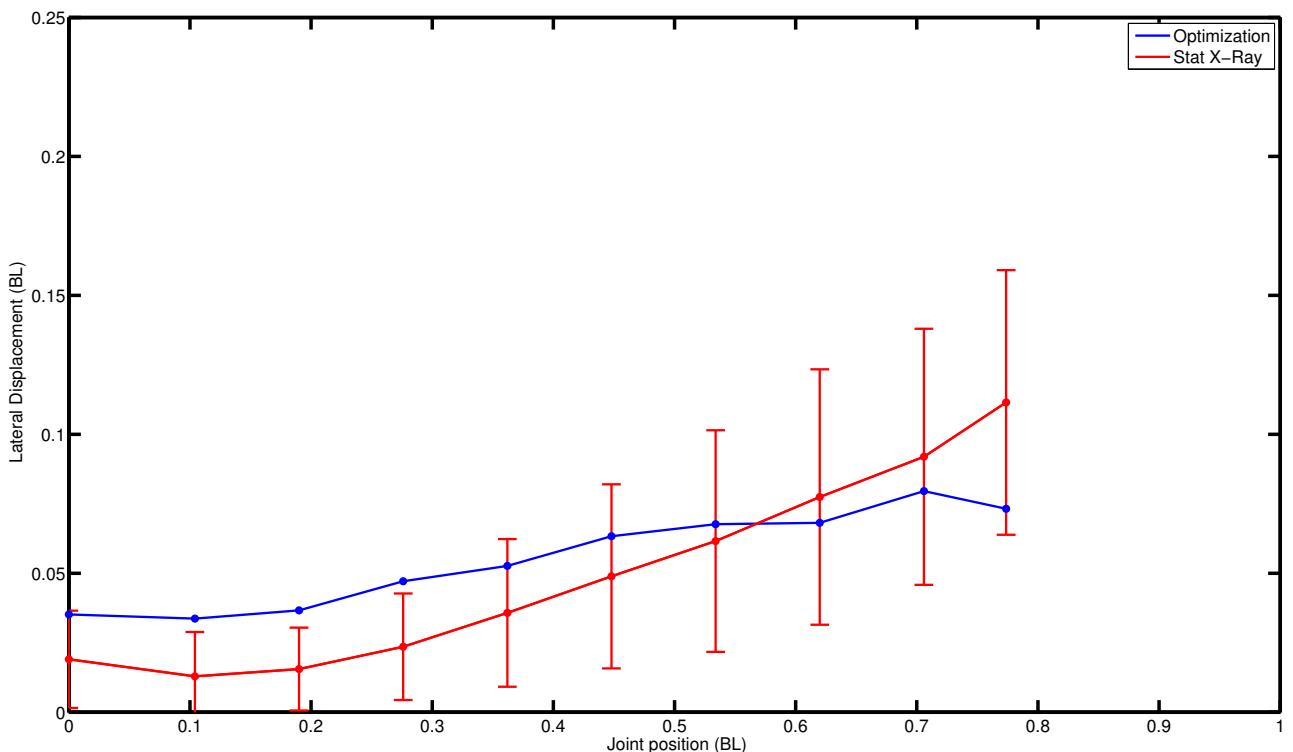


Figure 23.4: LateralDisplacementComp_Opti_9seg_tail_w62_Profile_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.035	NaN	NaN
Joint 1	0.034	0.148	NaN
Joint 2	0.037	0.111	1.020
Joint 3	0.047	0.178	0.444
Joint 4	0.053	0.221	0.785
Joint 5	0.063	0.326	0.849
Joint 6	0.068	0.294	0.797
Joint 7	0.068	0.489	0.763
Joint 8	0.080	0.586	1.901
Joint 9	0.073	NaN	NaN

Table 23.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.256	0.639	2.494

Table 23.3: Speed data

23.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Profile_1Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_Profile_1Hz_1.mp4

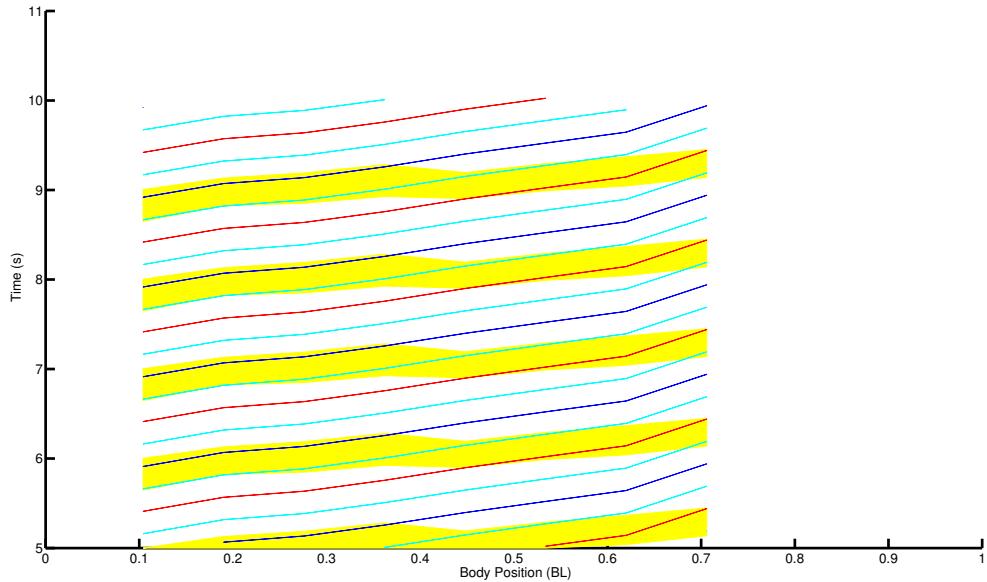


Figure 23.5: BodyMuscleActivity_Opti_9seg_tail_w62_Profile_1Hz_1

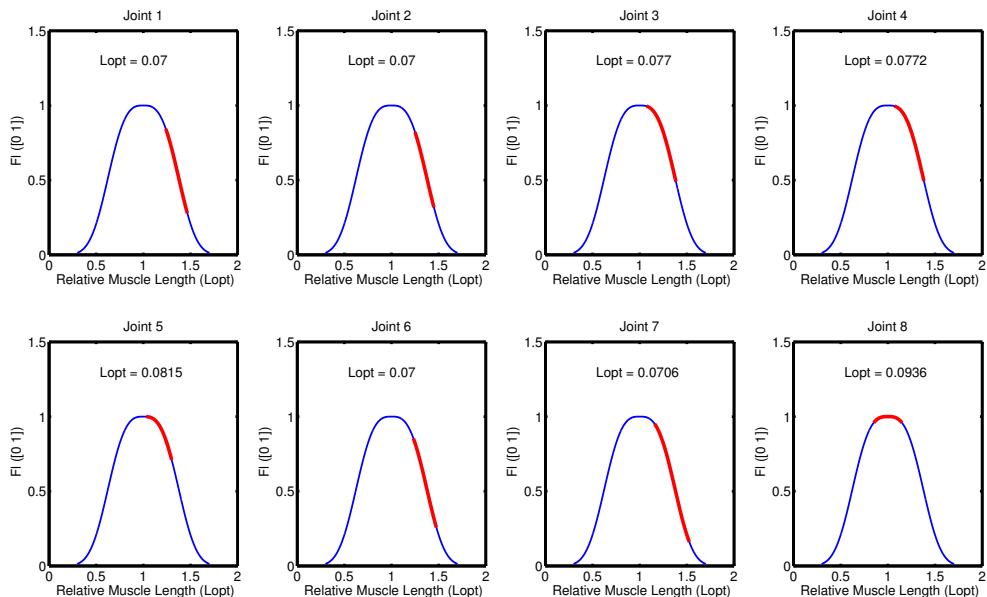


Figure 23.6: MuscleWorkingZone_Opti_9seg_tail_w62_Profile_1Hz_1

23.3 Energy

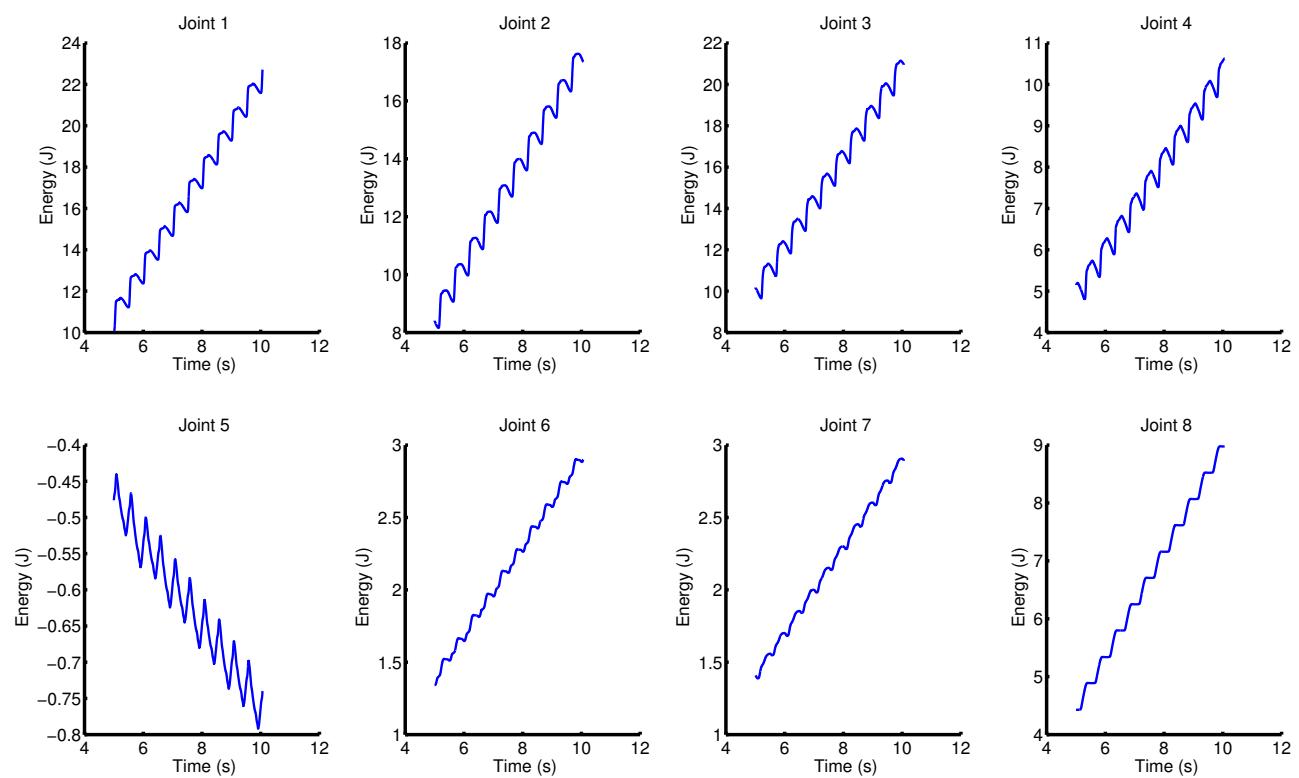


Figure 23.7: Energy_Opti_9seg_tail_w62_Profile_1Hz_1

24 Opti_9seg_notail_w62_shaped_Profile_1Hz_1

24.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_shaped_Profile_1Hz_1/Opti_9seg_notail_w62_shaped_Profile_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	15.383	16.999	16.131	12.068	7.111	4.174	2.287	1.131
Lopt (m)	0.070	0.071	0.094	0.086	0.078	0.086	0.076	0.100
r (m)	0.112	0.135	0.139	0.111	0.068	0.060	0.054	0.046
TimeLag (s)	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
error	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
Fitness	4.303	4.303	4.303	4.303	4.303	4.303	4.303	4.303

Table 24.1: Optimised Parameters

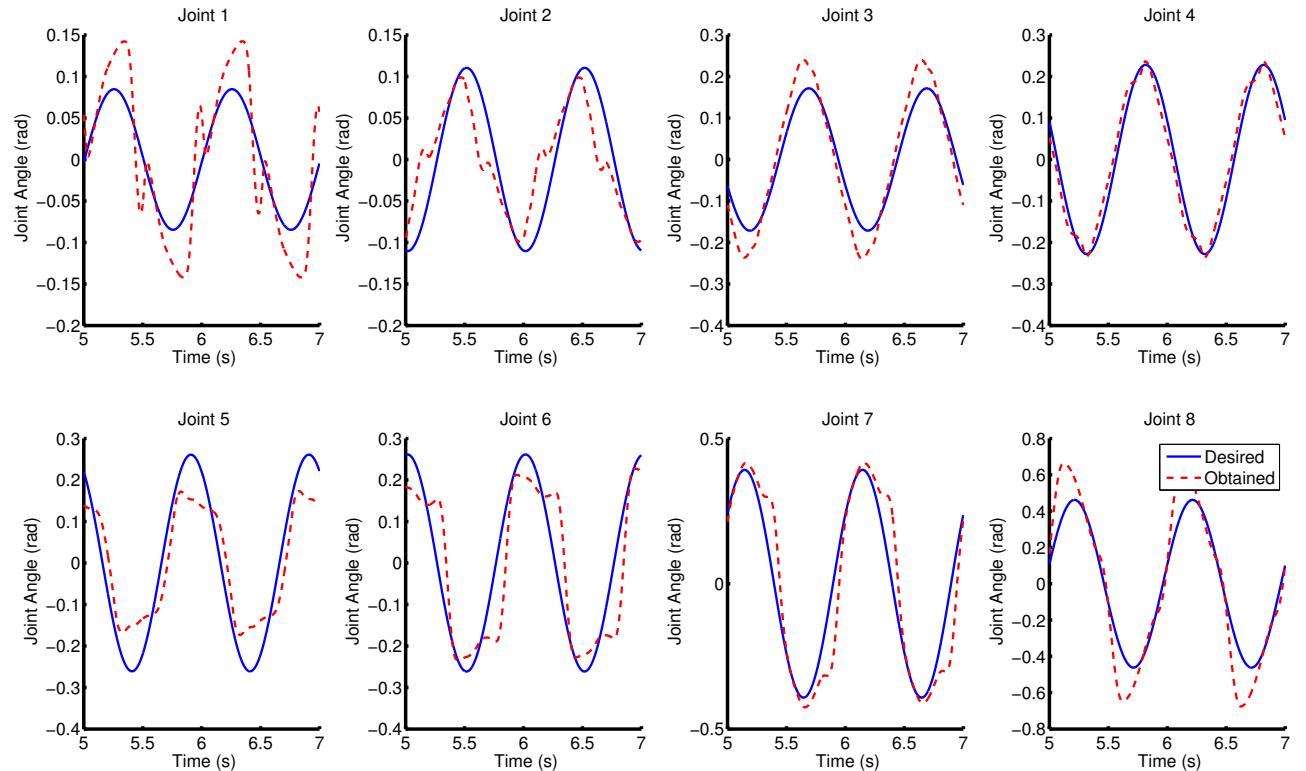


Figure 24.1: AngleDiff_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

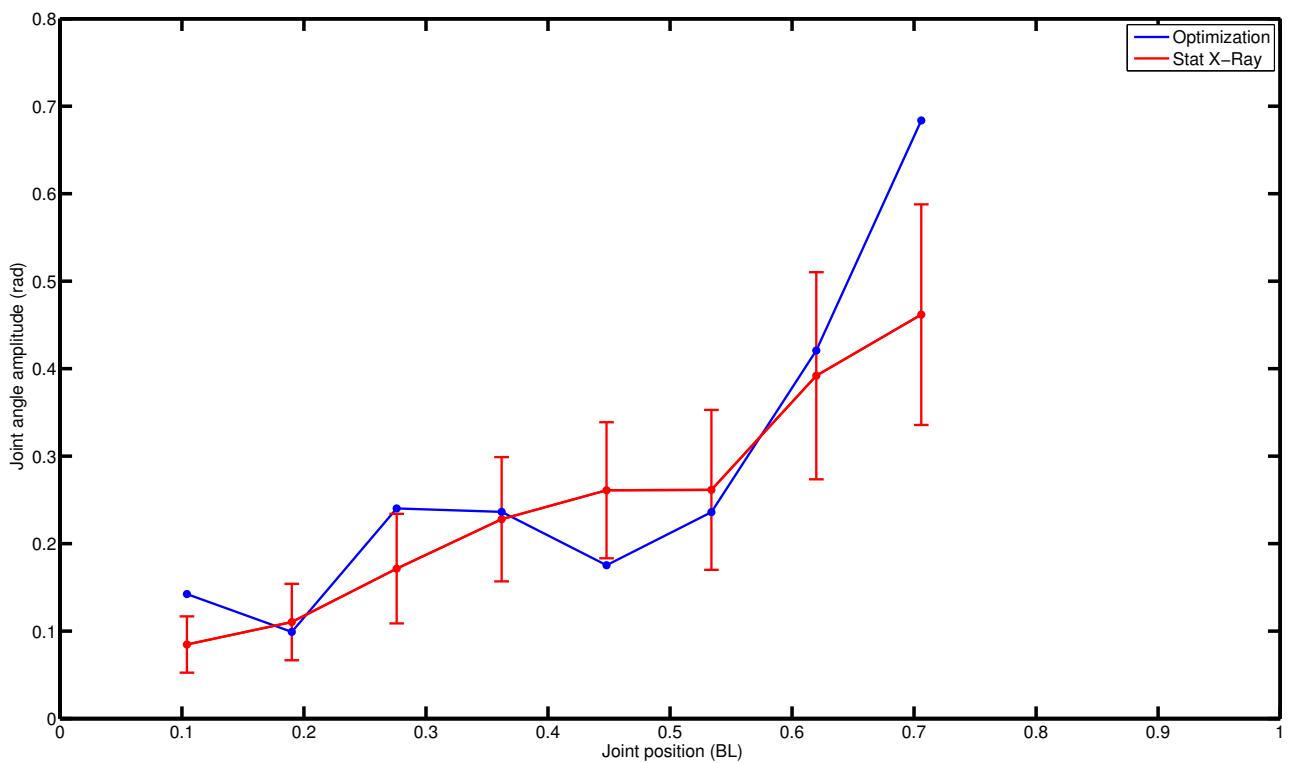


Figure 24.2: AngleAmplitudeComp_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

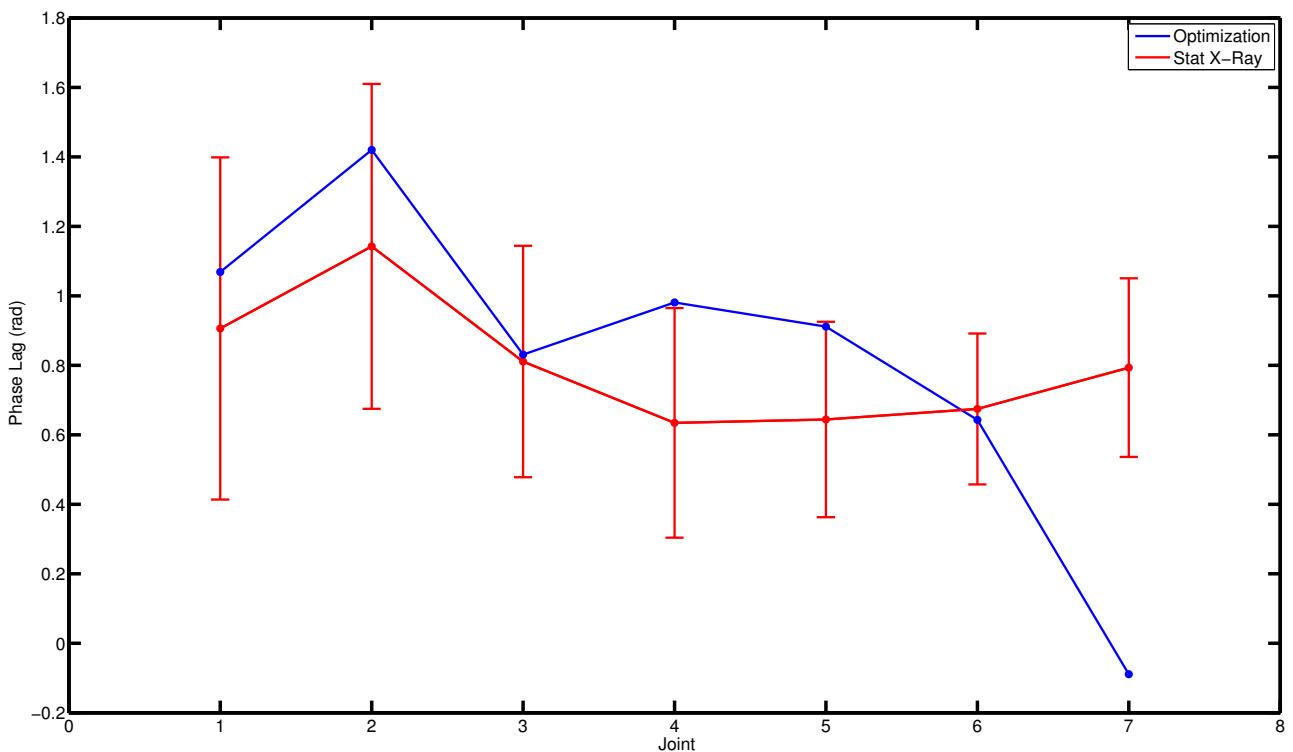


Figure 24.3: AnglePhaseLagComp_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

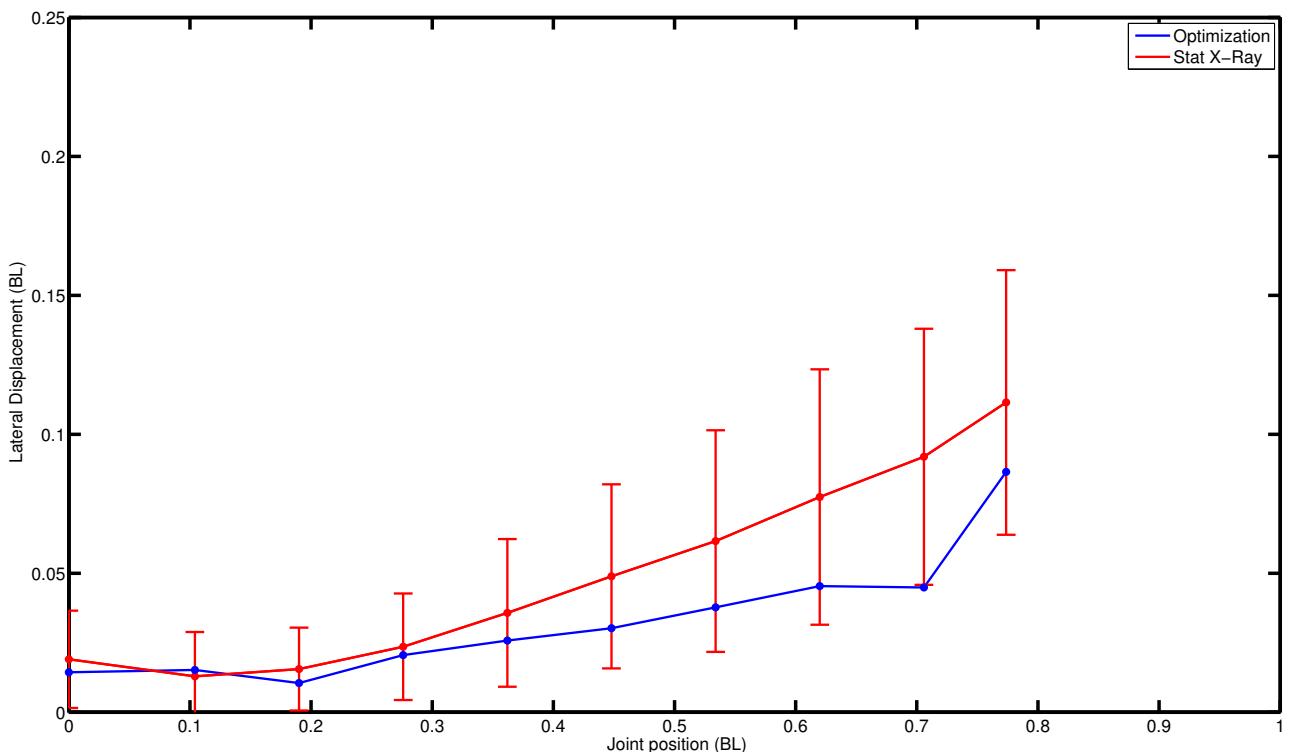


Figure 24.4: LateralDisplacementComp_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.014	NaN	NaN
Joint 1	0.015	0.142	NaN
Joint 2	0.010	0.099	1.069
Joint 3	0.021	0.240	1.420
Joint 4	0.026	0.236	0.831
Joint 5	0.030	0.175	0.981
Joint 6	0.038	0.236	0.911
Joint 7	0.045	0.421	0.643
Joint 8	0.045	0.684	-0.089
Joint 9	0.086	NaN	NaN

Table 24.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.145	0.366	2.523

Table 24.3: Speed data

24.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_shaped_Profile_1Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Profile_1Hz_1.mp4

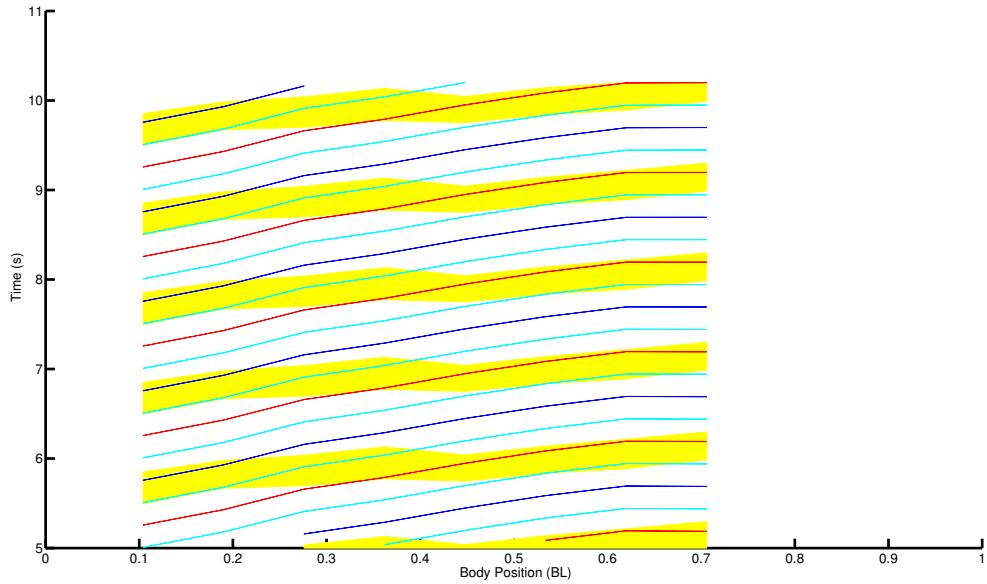


Figure 24.5: BodyMuscleActivity_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

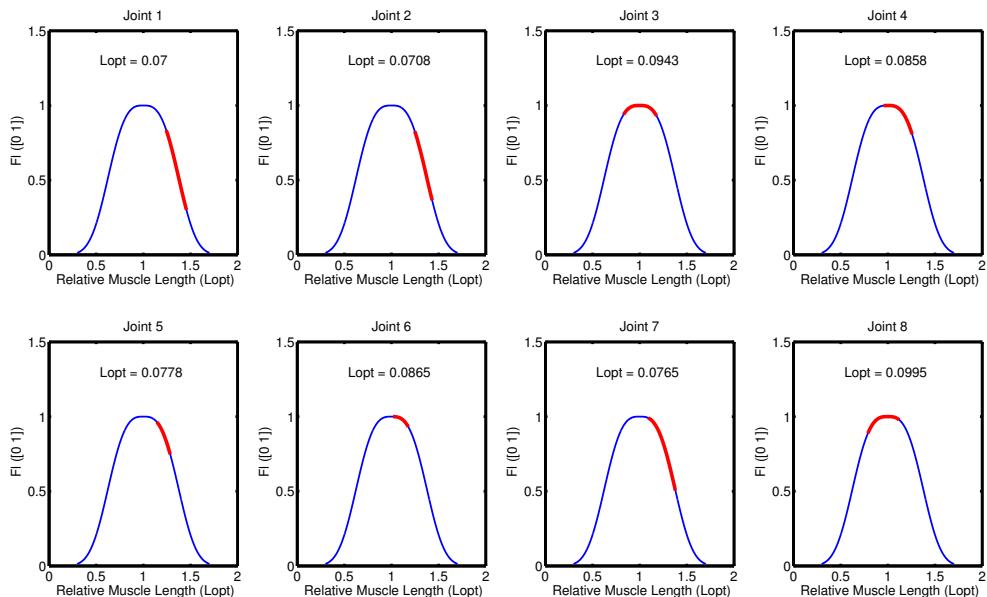


Figure 24.6: MuscleWorkingZone_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

24.3 Energy

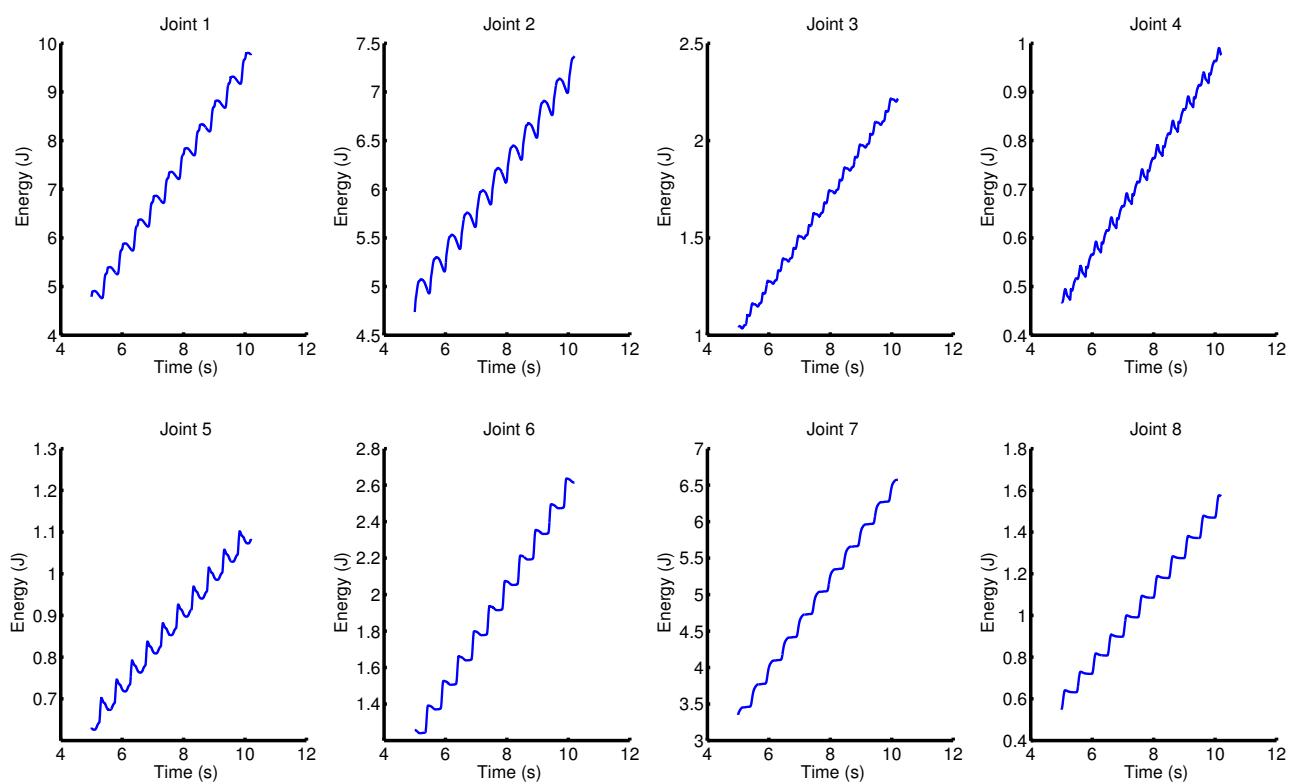


Figure 24.7: Energy_Opti_9seg_notail_w62_shaped_Profile_1Hz_1

25 Opti_9seg_tail_w62_shaped_Profile_1Hz_1

25.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_shaped_Profile_1Hz_1/Opti_9seg_tail_w62_shaped_Profile_1Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	25.210	27.858	26.436	19.777	11.653	6.840	3.748	1.853
Lopt (m)	0.070	0.145	0.103	0.091	0.070	0.135	0.078	0.078
r (m)	0.112	0.135	0.139	0.111	0.068	0.060	0.054	0.046
TimeLag (s)	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
error	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
Fitness	2.275	2.275	2.275	2.275	2.275	2.275	2.275	2.275

Table 25.1: Optimised Parameters

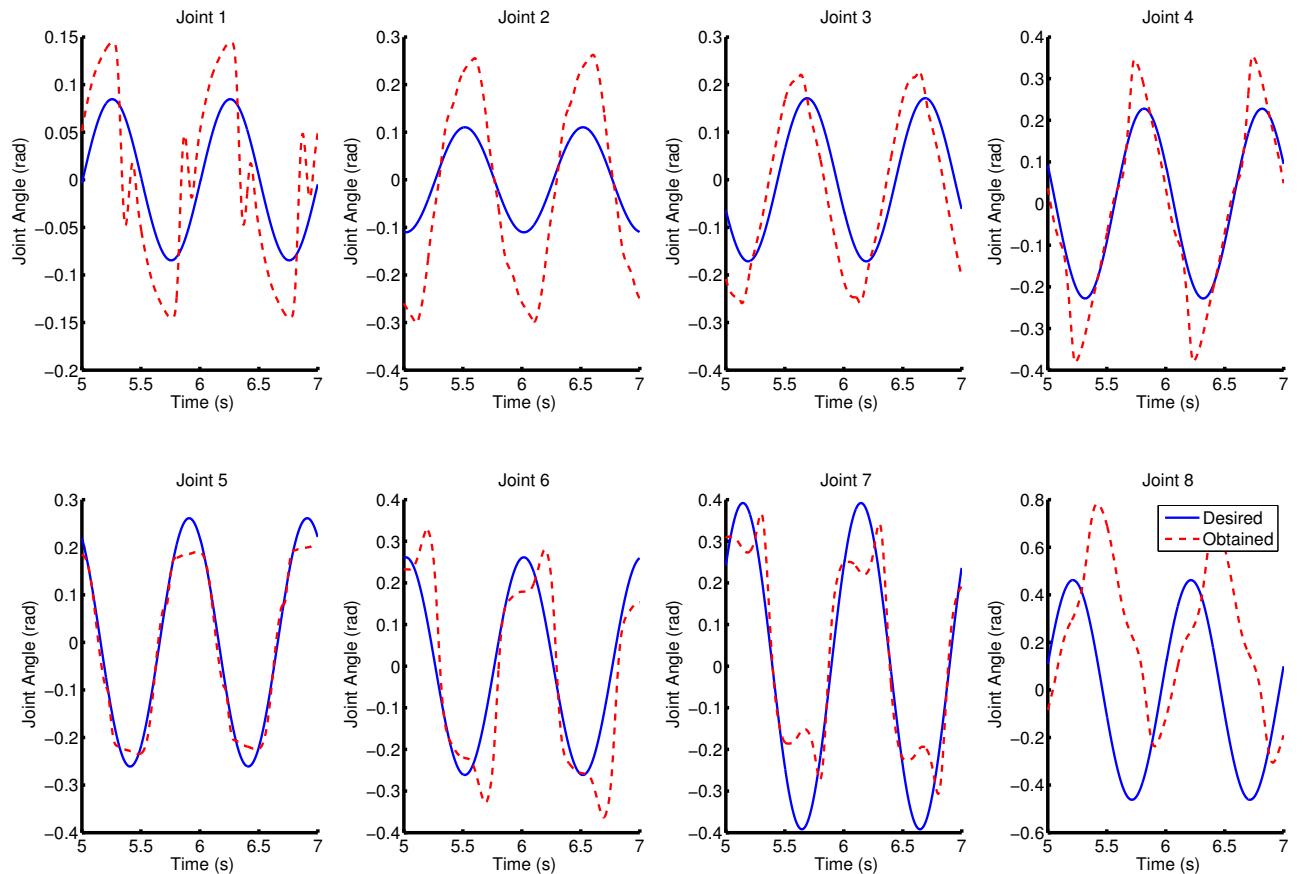


Figure 25.1: AngleDiff_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

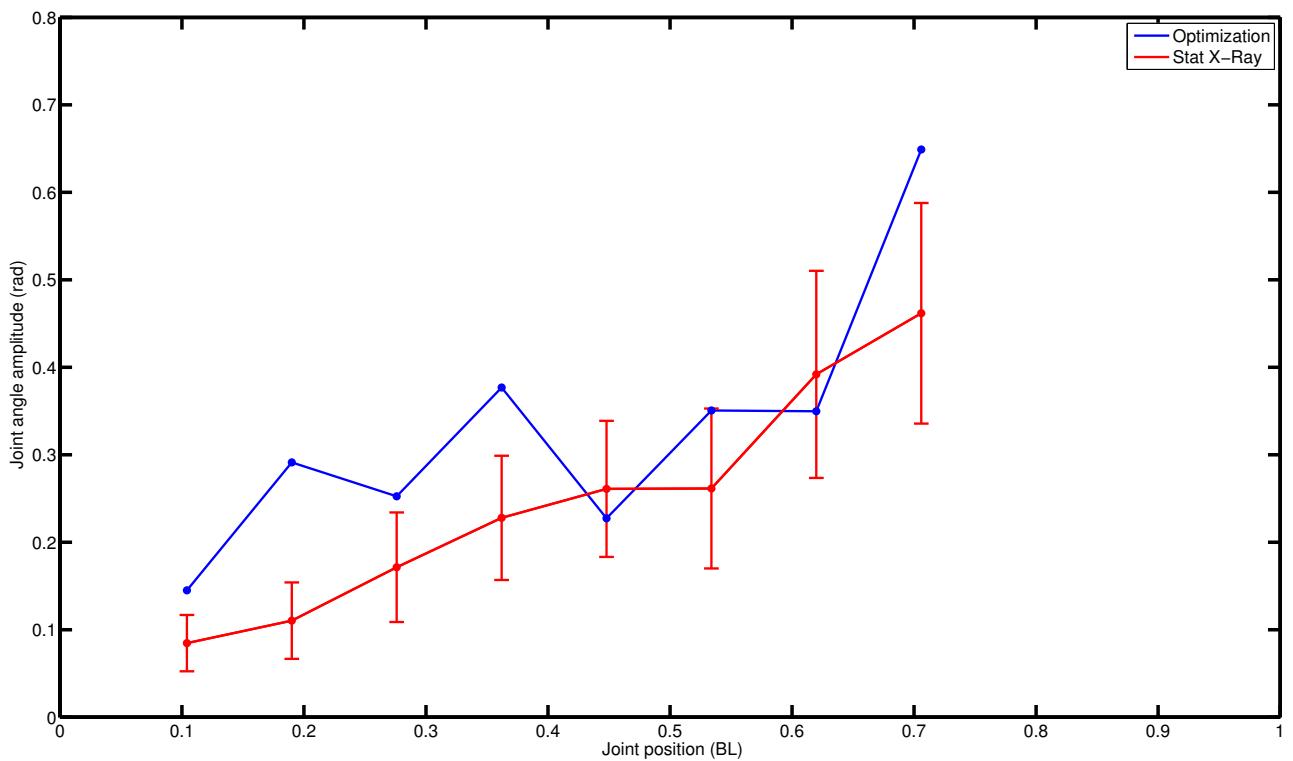


Figure 25.2: AngleAmplitudeComp_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

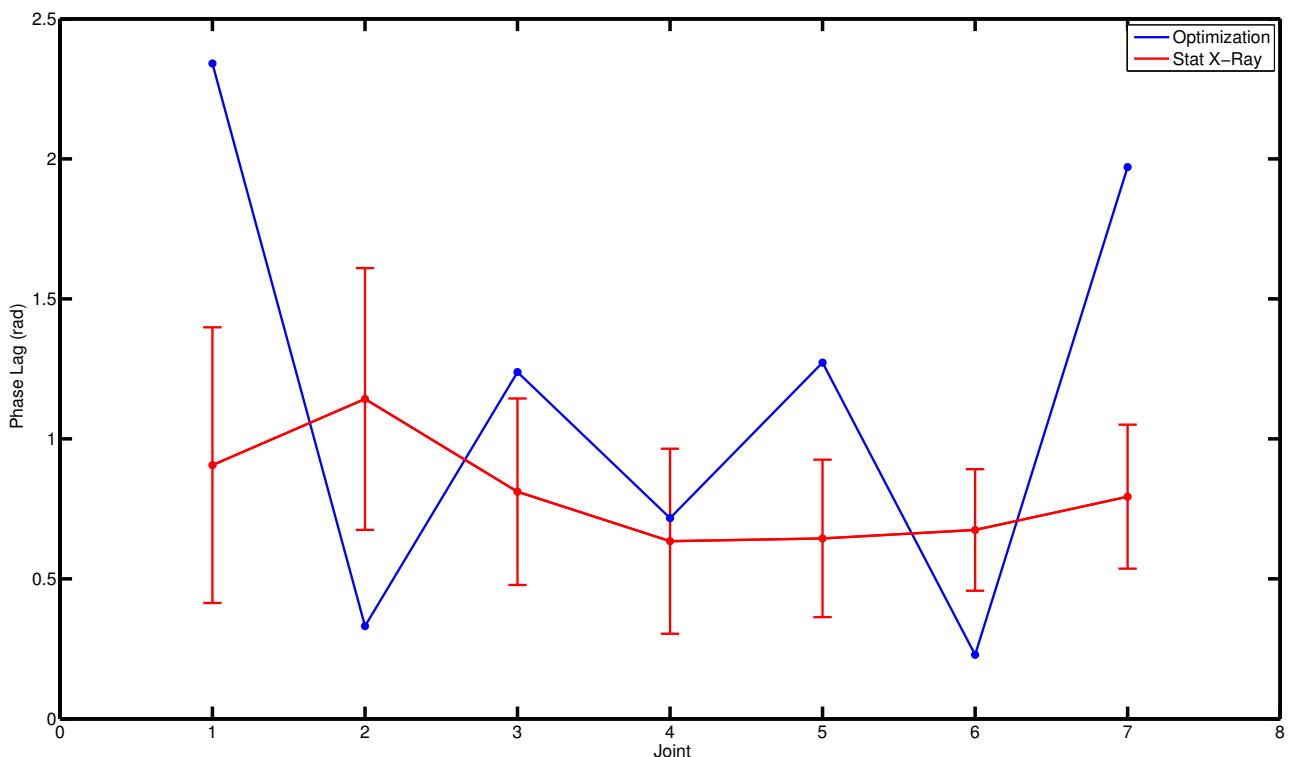


Figure 25.3: AnglePhaseLagComp_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

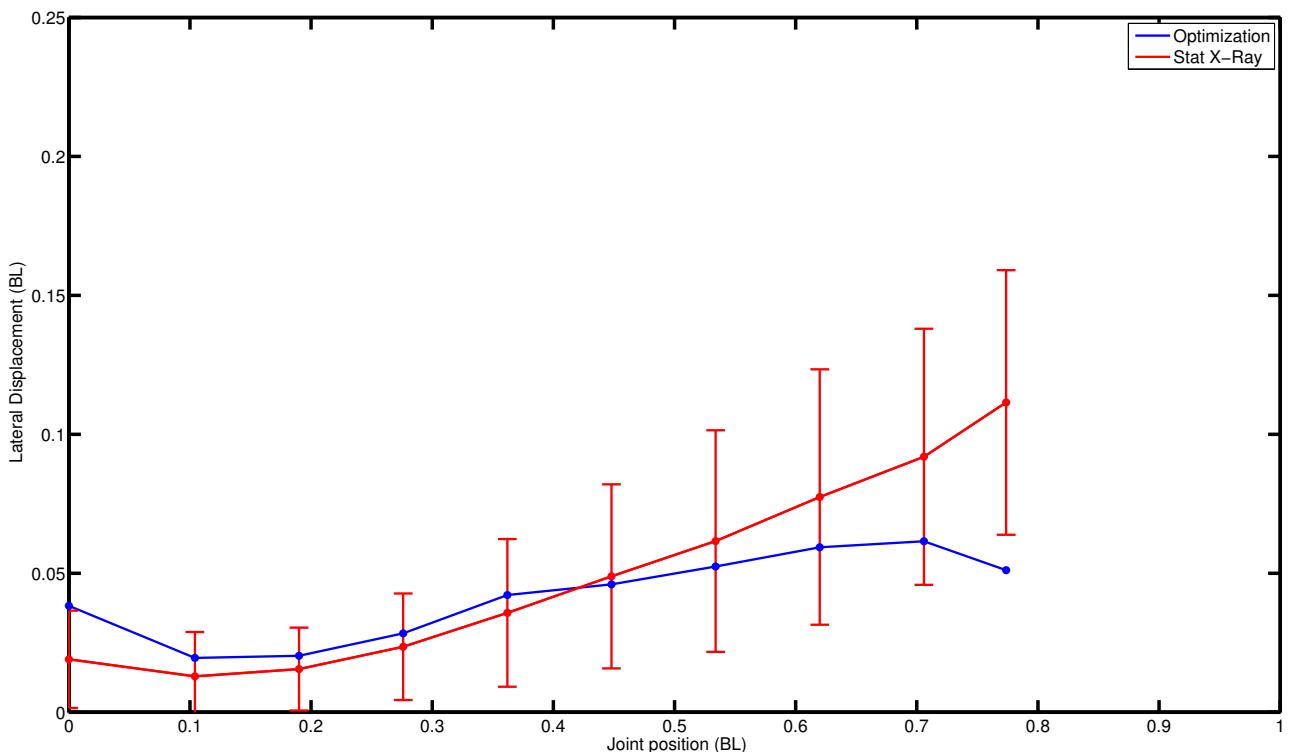


Figure 25.4: LateralDisplacementComp_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.038	NaN	NaN
Joint 1	0.020	0.145	NaN
Joint 2	0.020	0.291	2.341
Joint 3	0.028	0.252	0.331
Joint 4	0.042	0.377	1.239
Joint 5	0.046	0.227	0.717
Joint 6	0.052	0.351	1.272
Joint 7	0.059	0.350	0.229
Joint 8	0.061	0.649	1.971
Joint 9	0.051	NaN	NaN

Table 25.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.196	0.643	3.278

Table 25.3: Speed data

25.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_shaped_Profile_1Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Profile_1Hz_1.mp4

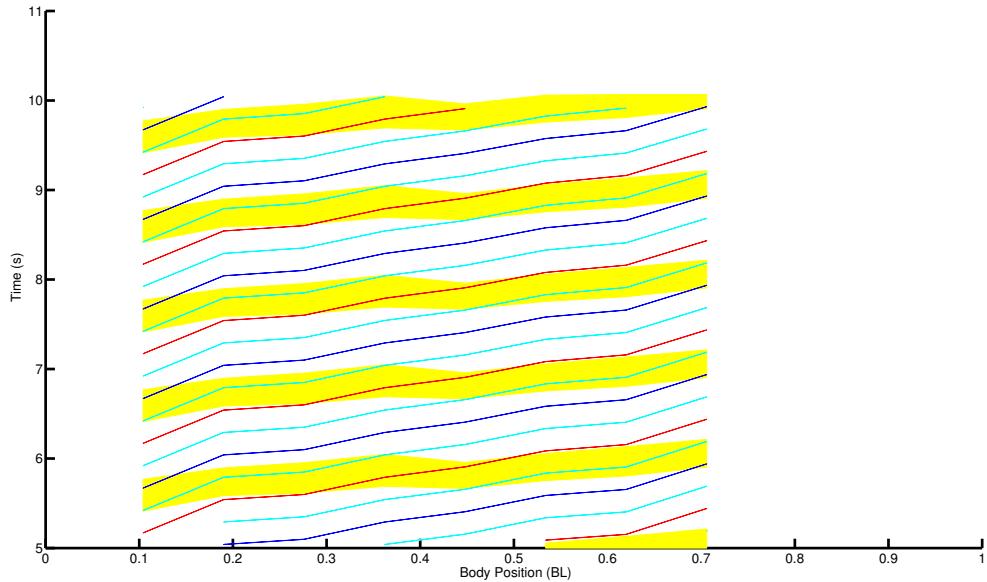


Figure 25.5: BodyMuscleActivity_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

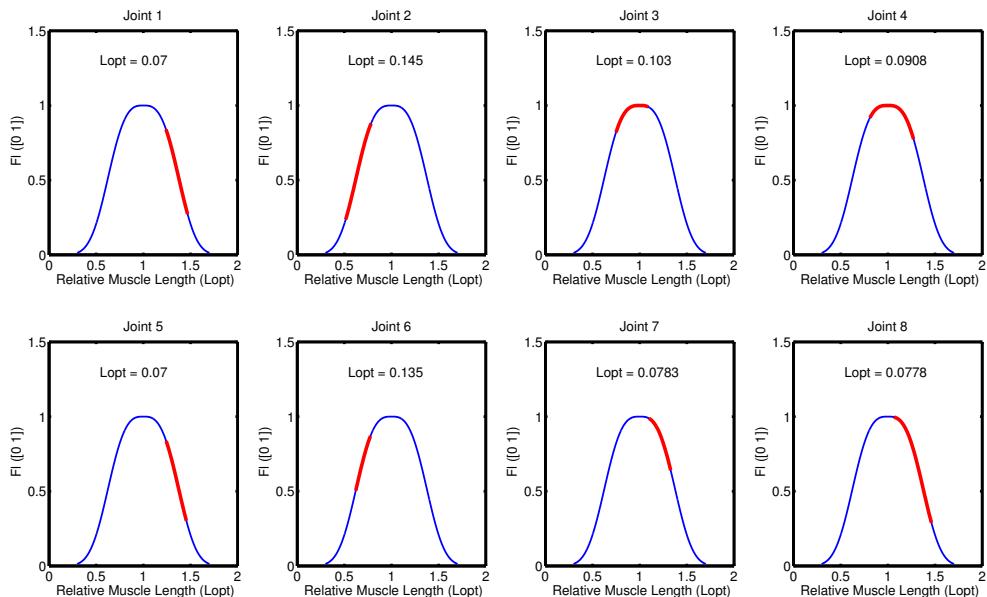


Figure 25.6: MuscleWorkingZone_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

25.3 Energy

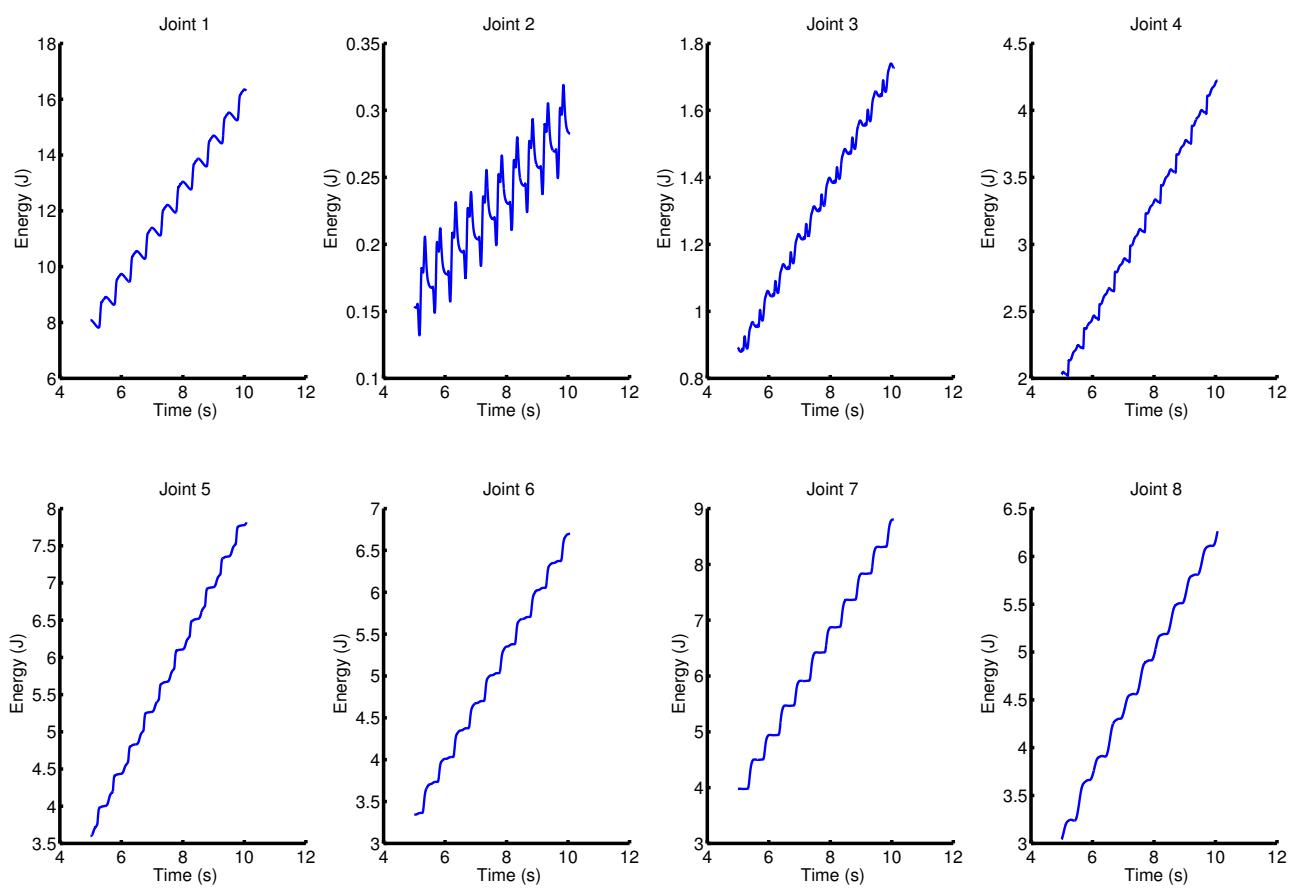


Figure 25.7: Energy_Opti_9seg_tail_w62_shaped_Profile_1Hz_1

26 Opti_9seg_notail_w62_Full_0_5Hz_1

26.1 Kinematics

Webots video : CD/Opti/Opti_9seg_notail_w62_Full_0_5Hz_1/Opti_9seg_notail_w62_Full_0_5Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	70.228	49.926	34.114	73.658	82.223	167.437	9.701	90.672
Lopt (m)	0.070	0.070	0.071	0.070	0.074	0.080	0.083	0.087
r (m)	0.139	0.139	0.134	0.134	0.103	0.129	0.140	0.116
TimeLag (s)	1.042	1.042	1.042	1.042	1.042	1.042	1.042	1.042
error	0.391	0.391	0.391	0.391	0.391	0.391	0.391	0.391
Fitness	2.560	2.560	2.560	2.560	2.560	2.560	2.560	2.560

Table 26.1: Optimised Parameters

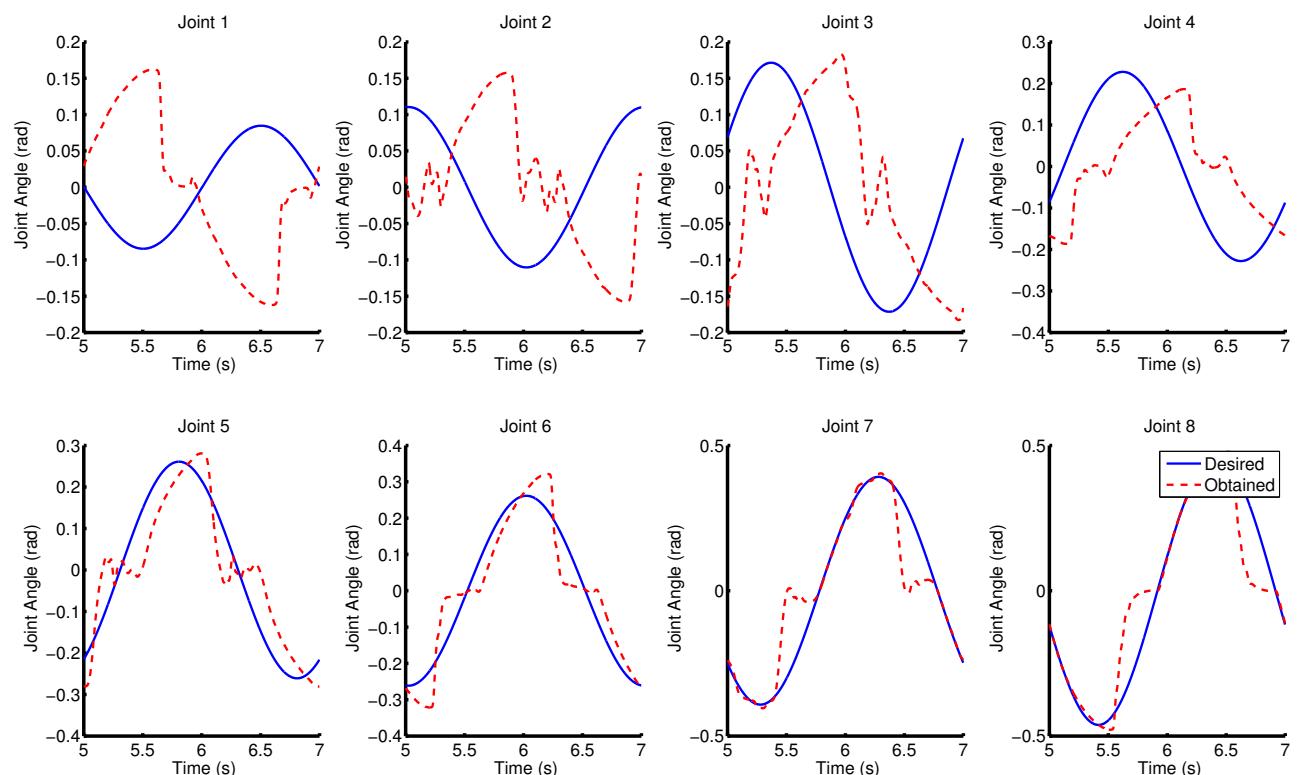


Figure 26.1: AngleDiff_Opti_9seg_notail_w62_Full_0_5Hz_1

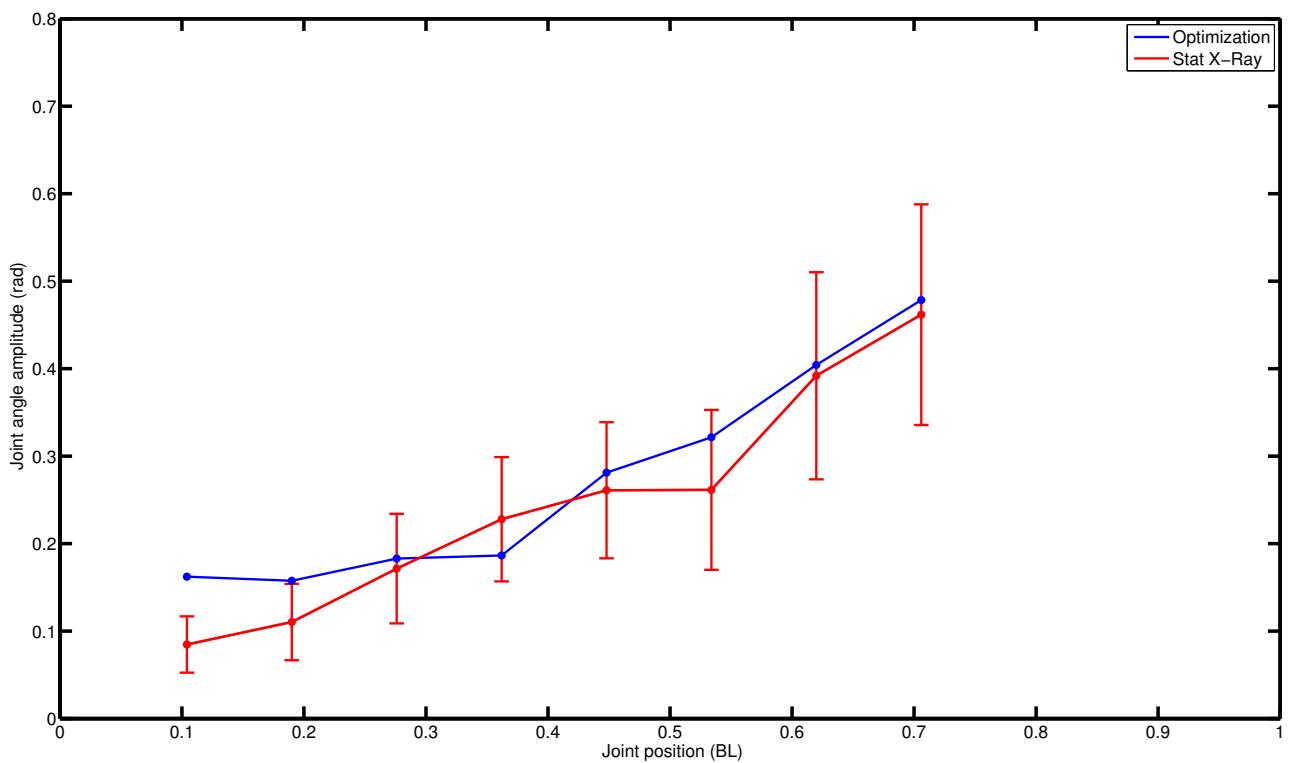


Figure 26.2: AngleAmplitudeComp_Opti_9seg_notail_w62_Full_0_5Hz_1

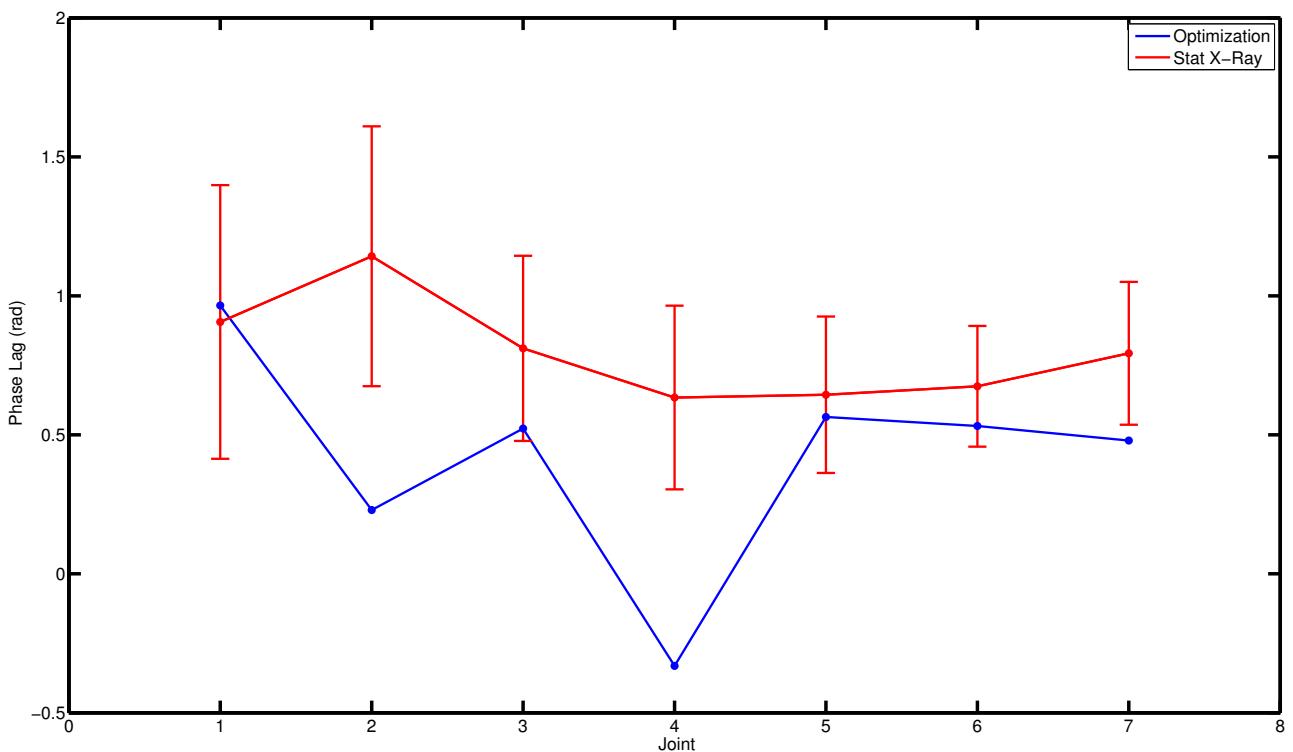


Figure 26.3: AnglePhaseLagComp_Opti_9seg_notail_w62_Full_0_5Hz_1

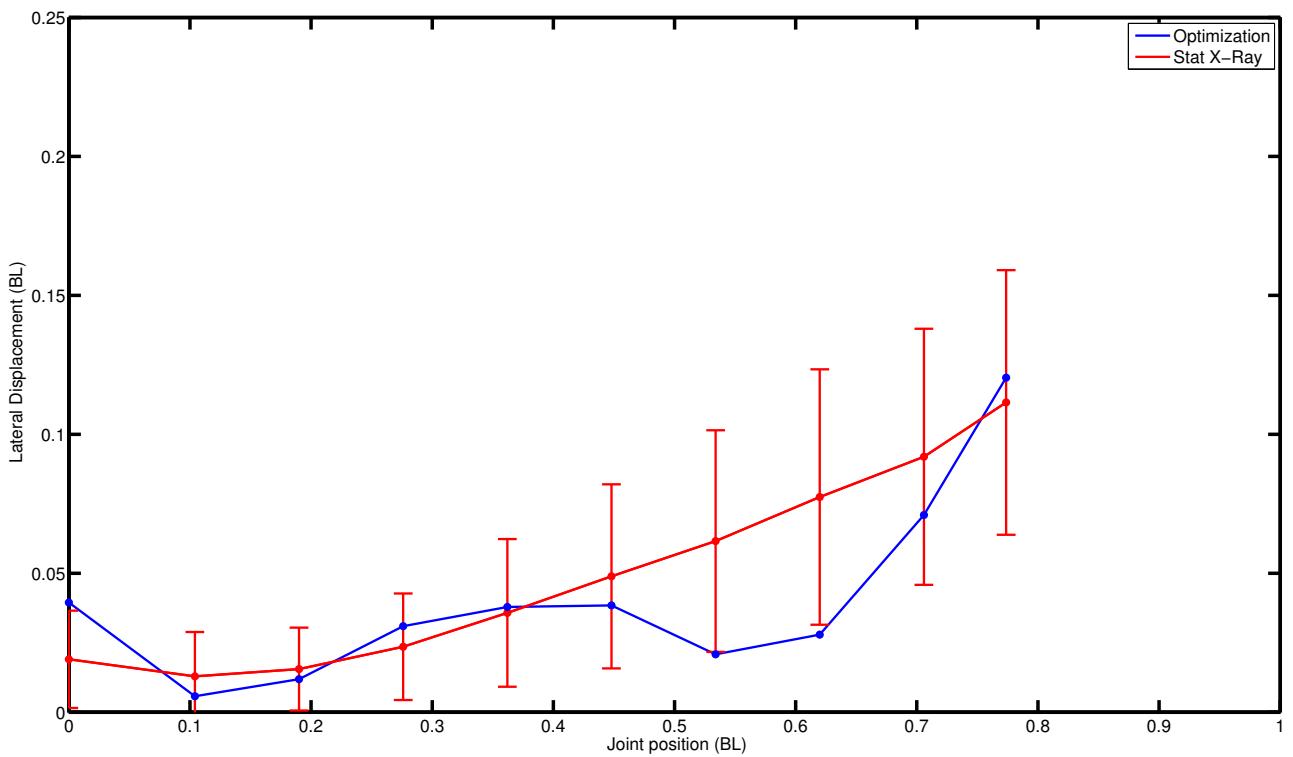


Figure 26.4: LateralDisplacementComp_Opti_9seg_notail_w62_Full_0_5Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.039	NaN	NaN
Joint 1	0.006	0.162	NaN
Joint 2	0.012	0.157	0.965
Joint 3	0.031	0.183	0.229
Joint 4	0.038	0.186	0.523
Joint 5	0.038	0.281	-0.332
Joint 6	0.021	0.322	0.564
Joint 7	0.028	0.404	0.532
Joint 8	0.071	0.478	0.479
Joint 9	0.120	NaN	NaN

Table 26.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.154	0.044	0.286

Table 26.3: Speed data

26.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_notail_w62_Full_0_5Hz_1/BodyMuscleActivity_Opti_9seg_notail_w62_Full_0_5Hz_1.mp4

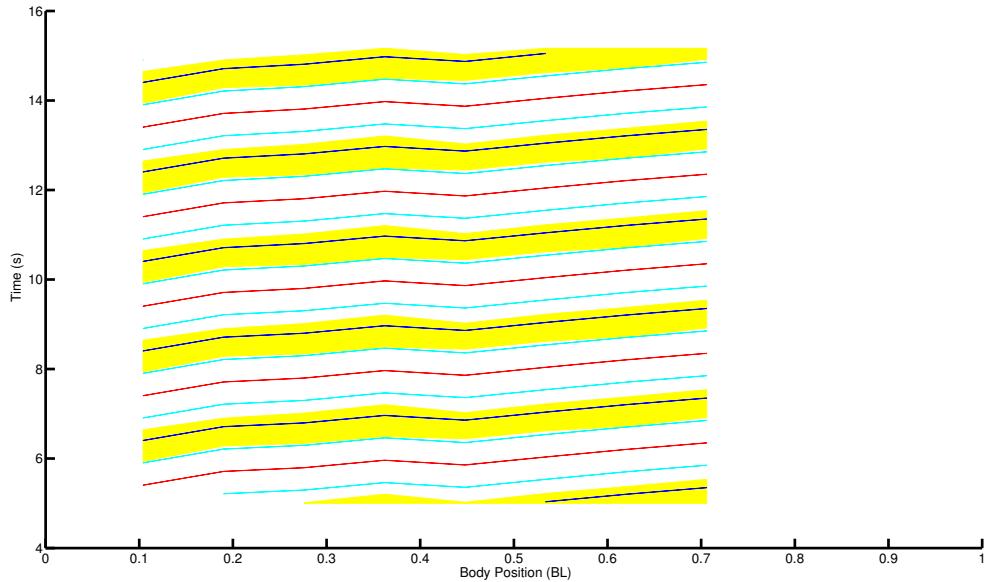


Figure 26.5: BodyMuscleActivity_Opti_9seg_notail_w62_Full_0_5Hz_1

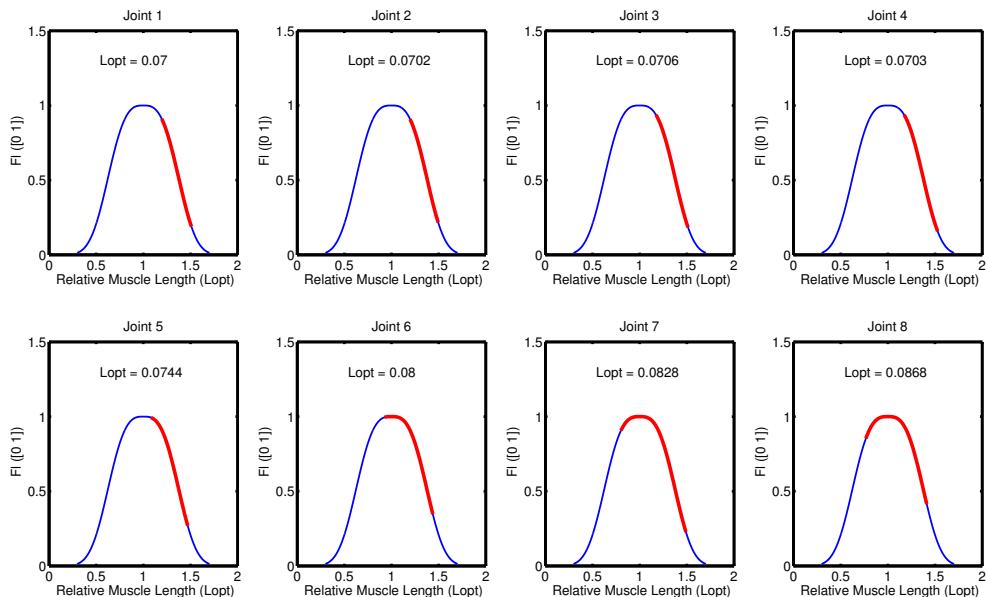


Figure 26.6: MuscleWorkingZone_Opti_9seg_notail_w62_Full_0_5Hz_1

26.3 Energy

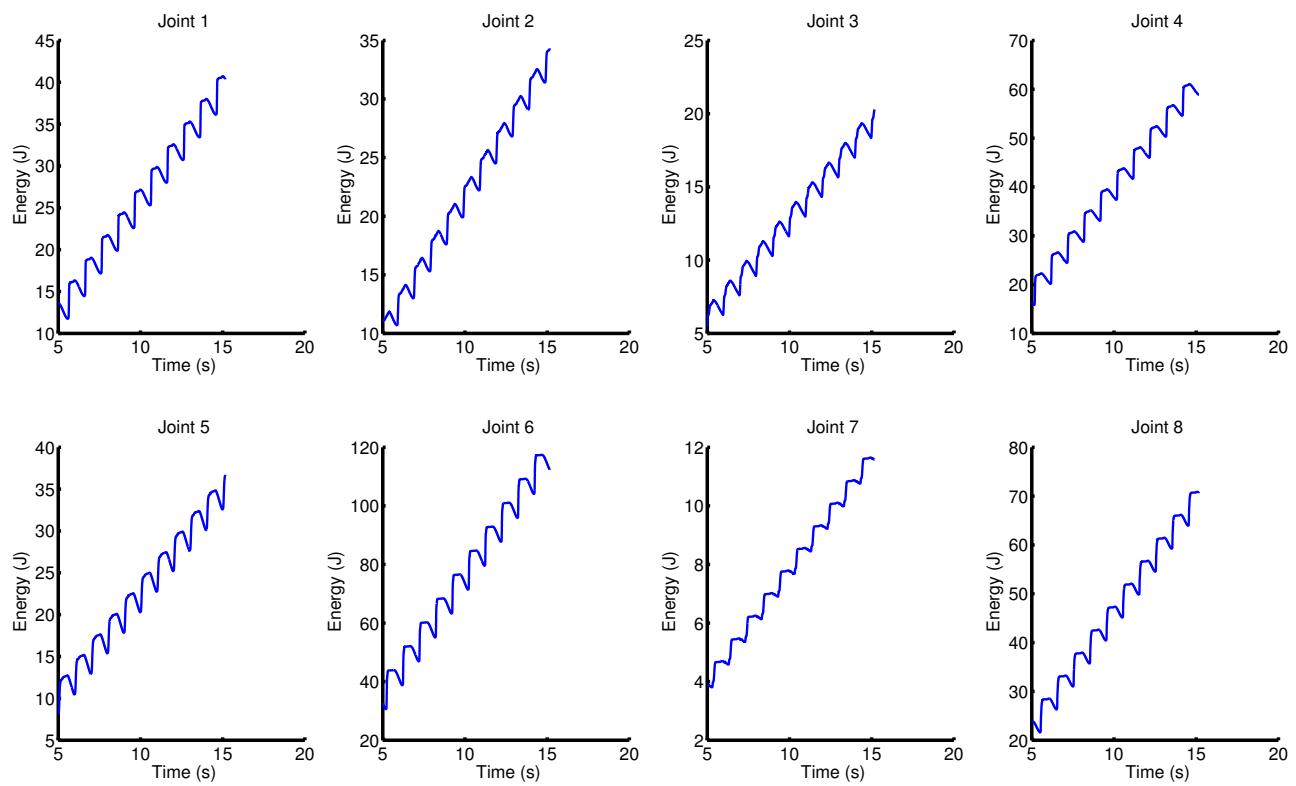


Figure 26.7: Energy_Opti_9seg_notail_w62_Full_0_5Hz_1

27 Opti_9seg_tail_w62_Full_0_5Hz_1

27.1 Kinematics

Webots video : CD/Opti/Opti_9seg_tail_w62_Full_0_5Hz_1/Opti_9seg_tail_w62_Full_0_5Hz_1.mpeg

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6	Joint 7	Joint 8
Fmax (N)	156.216	11.301	3.444	165.986	33.996	36.292	38.387	16.920
Lopt (m)	0.070	0.072	0.081	0.071	0.080	0.094	0.101	0.085
r (m)	0.126	0.140	0.098	0.111	0.118	0.134	0.129	0.108
TimeLag (s)	1.290	1.290	1.290	1.290	1.290	1.290	1.290	1.290
error	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302
Fitness	3.316	3.316	3.316	3.316	3.316	3.316	3.316	3.316

Table 27.1: Optimised Parameters

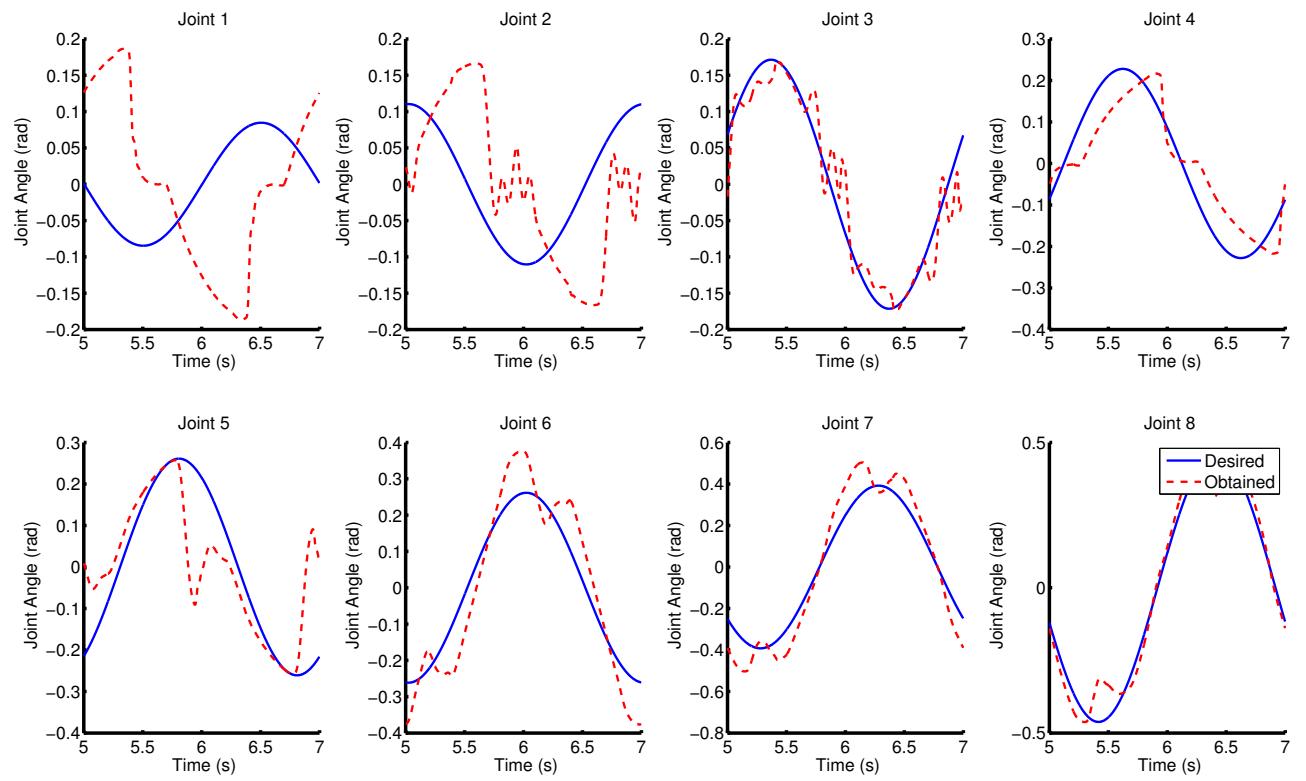


Figure 27.1: AngleDiff_Opti_9seg_tail_w62_Full_0_5Hz_1

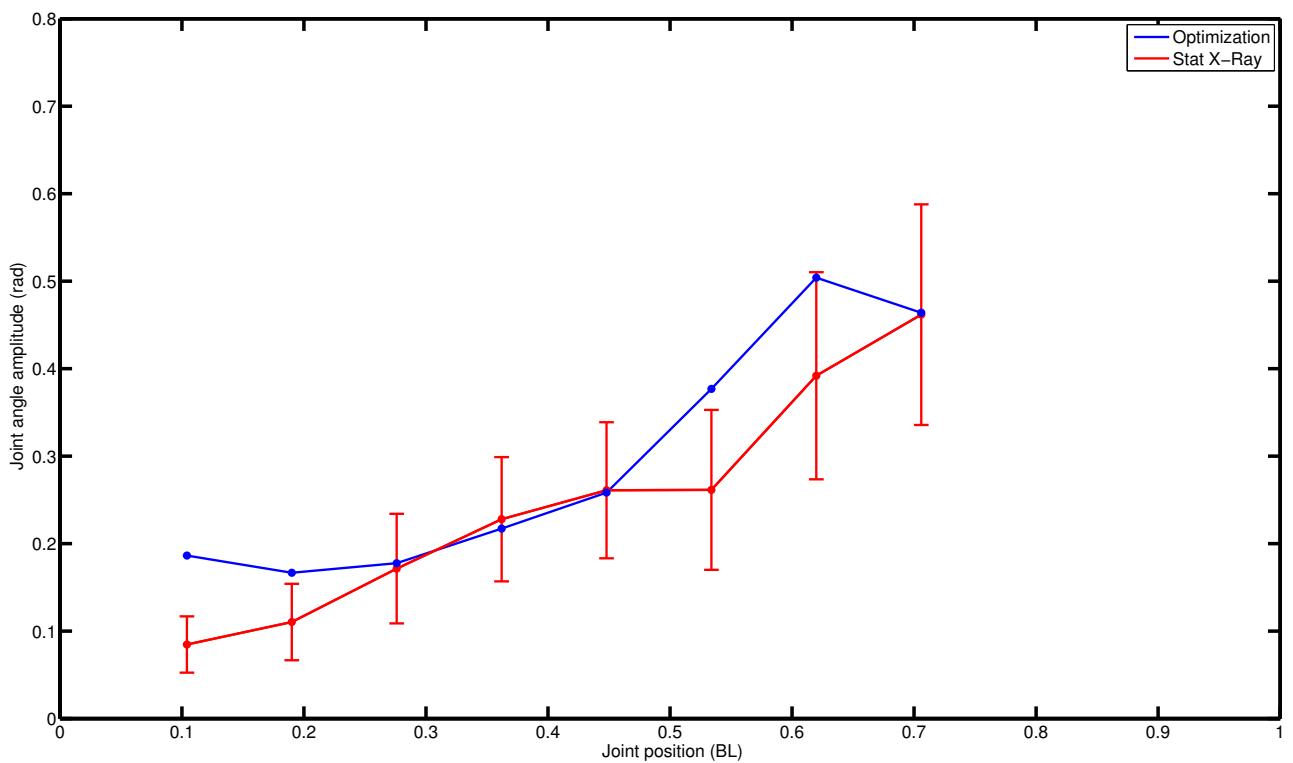


Figure 27.2: AngleAmplitudeComp_Opti_9seg_tail_w62_Full_0_5Hz_1

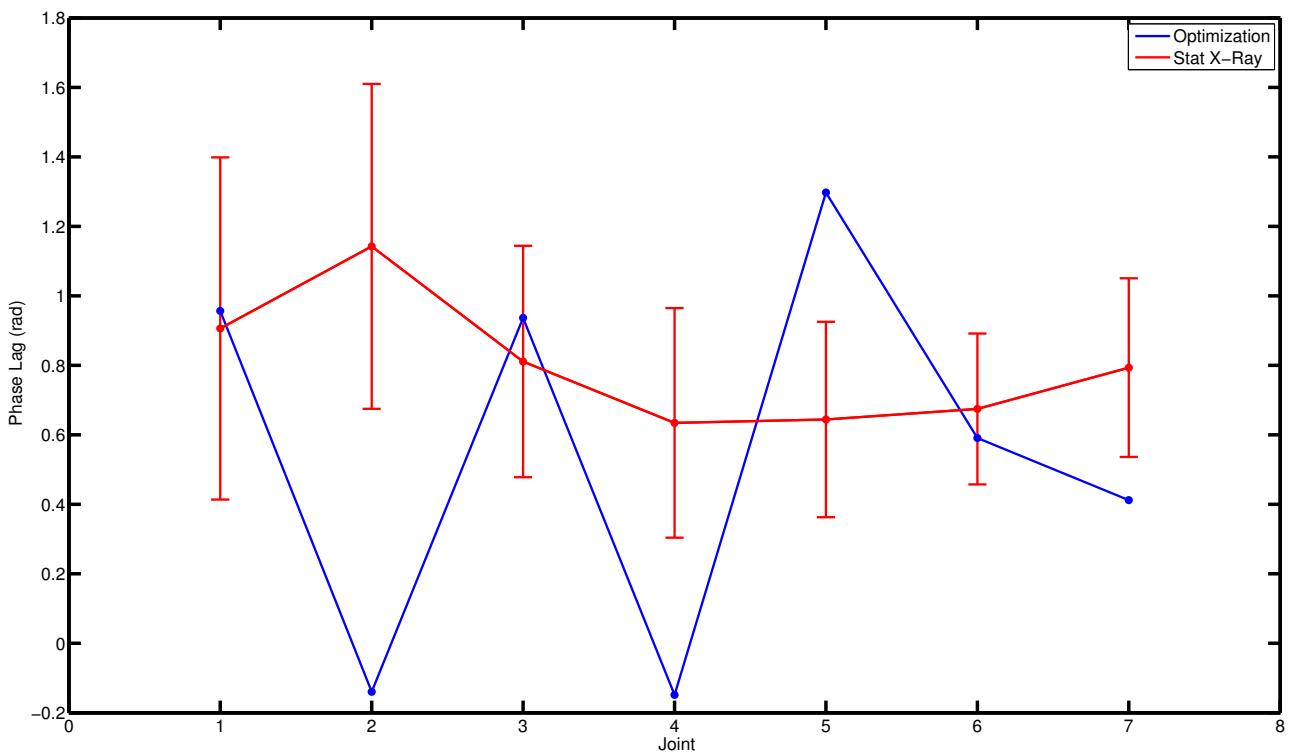


Figure 27.3: AnglePhaseLagComp_Opti_9seg_tail_w62_Full_0_5Hz_1

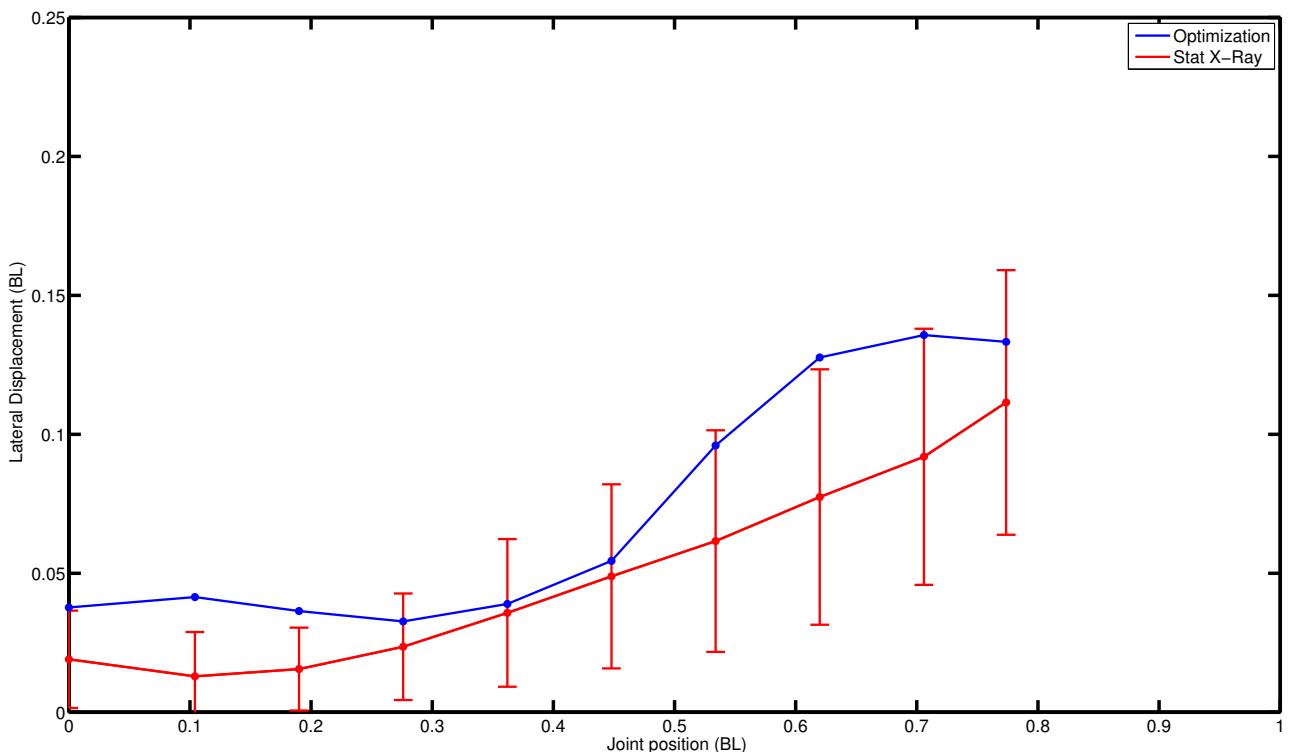


Figure 27.4: LateralDisplacementComp_Opti_9seg_tail_w62_Full_0_5Hz_1

	Lateral Displacement (BL)	Angle Amplitude (rad)	Phase Lag (rad)
Joint 0	0.038	NaN	NaN
Joint 1	0.041	0.186	NaN
Joint 2	0.036	0.167	0.957
Joint 3	0.033	0.178	-0.140
Joint 4	0.039	0.217	0.937
Joint 5	0.054	0.258	-0.149
Joint 6	0.096	0.377	1.298
Joint 7	0.128	0.504	0.591
Joint 8	0.136	0.464	0.412
Joint 9	0.133	NaN	NaN

Table 27.2: Swimming data

Robot Speed (BL/s)	Backward-travelling Wave Speed (BL/s)	Ratio
0.314	0.513	1.633

Table 27.3: Speed data

27.2 Timing and Working zone

Matlab video : CD/Opti/Opti_9seg_tail_w62_Full_0_5Hz_1/BodyMuscleActivity_Opti_9seg_tail_w62_Full_0_5Hz_1.mp4

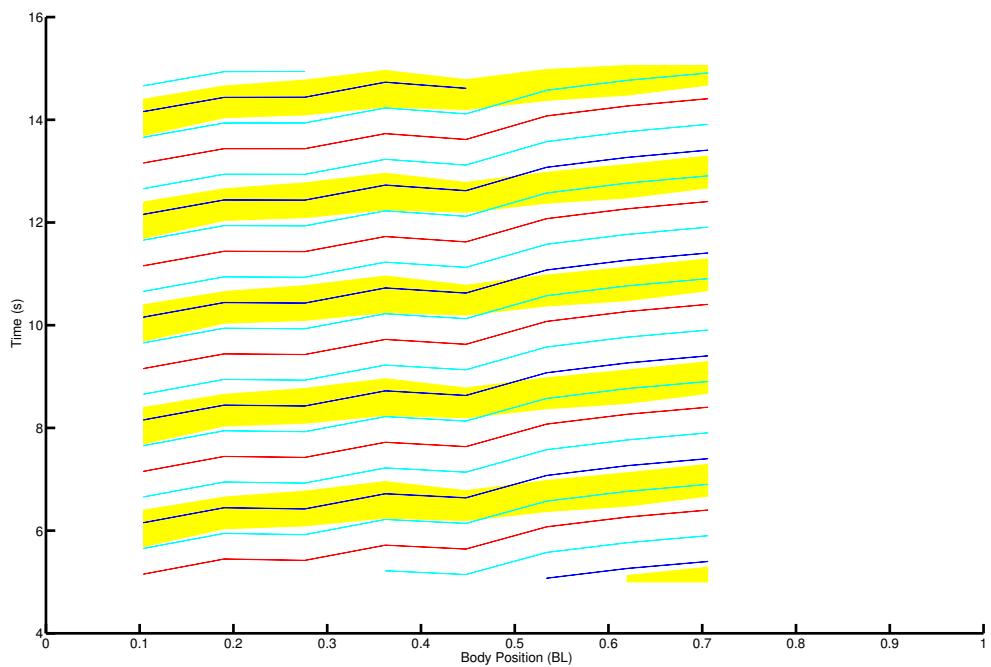


Figure 27.5: BodyMuscleActivity_Opti_9seg_tail_w62_Full_0_5Hz_1

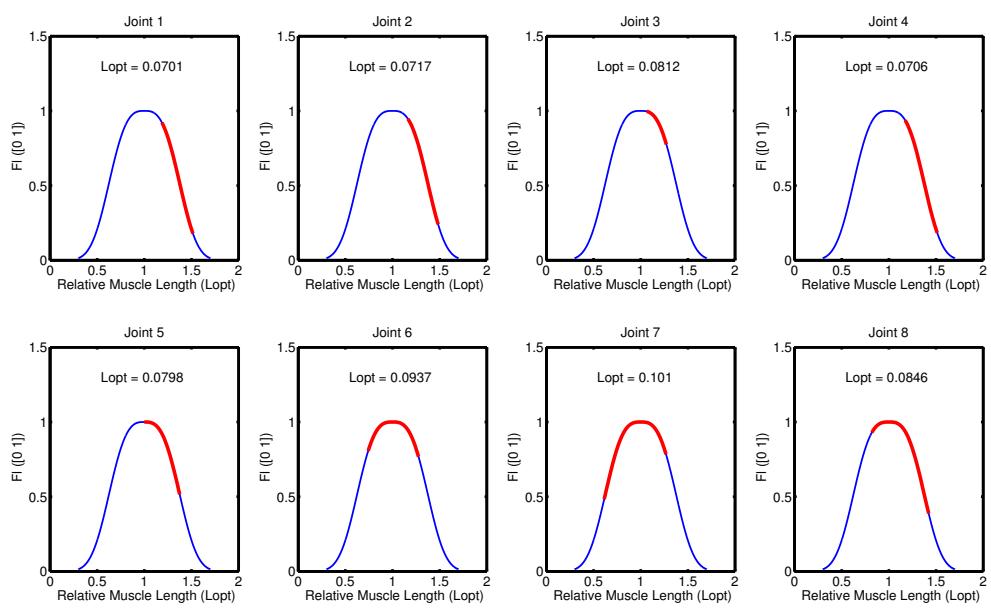


Figure 27.6: MuscleWorkingZone_Opti_9seg_tail_w62_Full_0_5Hz_1

27.3 Energy

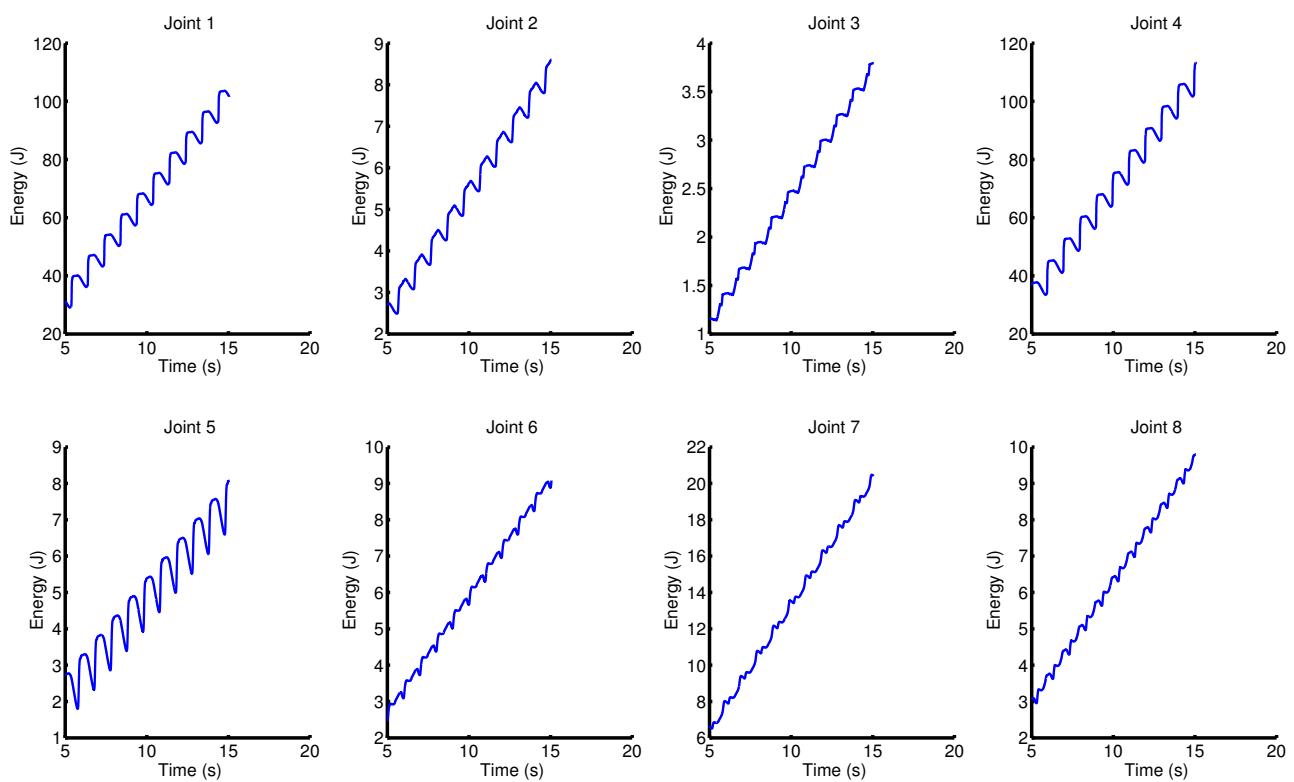


Figure 27.7: Energy_Opti_9seg_tail_w62_Full_0_5Hz_1