COMP0130: ROBOT VISION AND NAVIGATION
Workshop 3: Multisensor Navigation
ANSWERS

Task 1: Car Dead Reckoning

The position and velocity solution is as follows:

Time (s)	Latitude (°)	Longitude (°)	Damped Instantaneous Velocity (m/s) North	East
0	50.424958	-3.595797	-0.30	10.22
0.5	50.424956	-3.595725	-0.44	10.21
1	50.424956	-3.595654	0.16	10.21
1.5	50.424957	-3.595582	0.15	10.12
2	50.424956	-3.595510	-0.25	10.26
2.5	50.424955	-3.595439	-0.21	10.16
3	50.424955	-3.595367	0.08	10.19
3.5	50.424954	-3.595295	-0.34	10.19
4	50.424953	-3.595224	-0.30	10.09
4.5	50.424953	-3.595152	0.12	10.24
5	50.424954	-3.595081	0.47	10.09
10	50.424958	-3.594367	0.12	10.33
15	50.424952	-3.593488	0.08	14.92
20	50.424949	-3.592250	0.07	19.92
25	50.424964	-3.590818	1.36	20.41
30	50.424950	-3.589383	-1.29	20.34
35	50.424937	-3.588112	0.21	15.81
40	50.424925	-3.587197	-0.33	10.76
45	50.424475	-3.587060	-13.47	-0.09
50	50.423760	-3.587073	-18.41	-0.21
55	50.422861	-3.587057	-20.54	0.46
60	50.421944	-3.587049	-20.37	1.34
65	50.421038	-3.586886	-19.39	6.64
70	50.420235	-3.586197	-17.62	10.31
75	50.419442	-3.585476	-17.83	10.24
80	50.418624	-3.584715	-20.33	11.43
85	50.417623	-3.583797	-23.98	15.07
90	50.416454	-3.582730	-26.34	15.28
95	50.415267	-3.581647	-26.15	16.05
100	50.414030	-3.580740	-29.95	5.23
105	50.412658	-3.580668	-30.38	-2.12
110	50.411283	-3.580660	-30.43	0.85
115	50.409957	-3.580670	-26.51	0.30
120	50.408968	-3.580659	-17.73	0.08
125	50.408357	-3.580658	-9.47	-0.02
130	50.408162	-3.580512	-0.15	4.07

Time (s)	Latitude (°)	Longitude (°)	Damped Instantaneous Velocity (m/s) North	East
135	50.408161	-3.580388	0.00	0.04
140	50.408161	-3.580388	-0.01	0.10
145	50.408161	-3.580389	0.00	0.01
150	50.408161	-3.580389	0.00	-0.02
155	50.408161	-3.580389	0.00	0.09
160	50.408161	-3.580388	0.00	0.09
165	50.408161	-3.580389	0.00	0.03
170	50.408161	-3.580389	0.00	-0.14
175	50.408161	-3.580390	0.00	0.04

Task 2: Car DR/GNSS Integration

The position and velocity solution is as follows:

Time (s)	Latitude (°)	Longitude (°)	Velocity (m/s) North	East
0	50.424958	-3.595797	-0.05	10.03
0.5	50.424948	-3.595737	0.01	10.01
1	50.424943	-3.595669	0.00	9.99
1.5	50.424941	-3.595599	-0.03	10.02
2	50.424939	-3.595528	-0.02	10.01
2.5	50.424939	-3.595458	0.00	10.03
3	50.424939	-3.595388	-0.01	10.01
3.5	50.424939	-3.595318	-0.01	10.01
4	50.424938	-3.595249	-0.01	10.00
4.5	50.424938	-3.595179	0.02	10.00
5	50.424938	-3.595109	-0.01	10.01
10	50.424937	-3.594407	-0.04	10.00
15	50.424938	-3.593528	0.04	15.00
20	50.424938	-3.592295	0.02	20.01
25	50.424938	-3.590888	-0.01	20.02
30	50.424937	-3.589481	-0.03	20.01
35	50.424937	-3.588252	0.01	14.99
40	50.424936	-3.587376	0.00	10.00
45	50.424488	-3.587234	-13.37	0.00
50	50.423775	-3.587233	-18.31	0.00
55	50.422888	-3.587233	-19.99	0.00
60	50.421990	-3.587231	-20.00	0.00
65	50.421103	-3.587073	-18.91	6.52
70	50.420310	-3.586414	-17.34	10.00
75	50.419532	-3.585710	-17.34	10.00
80	50.418715	-3.584972	-19.96	11.54
85	50.417719	-3.584071	-24.33	14.05
90	50.416565	-3.583030	-26.01	15.01
95	50.415398	-3.581975	-26.01	15.00

Time (s)	Latitude (°)	Longitude (°)	Velocity (m/s) North	East
100	50.414178	-3.581105	-29.28	6.53
105	50.412835	-3.581006	-30.01	-0.01
110	50.411487	-3.581004	-30.00	0.02
115	50.410199	-3.581003	-25.37	0.01
120	50.409249	-3.581003	-17.03	0.02
125	50.408674	-3.581002	-8.67	0.01
130	50.408494	-3.580856	-0.02	3.87
135	50.408493	-3.580753	-0.02	-0.01
140	50.408493	-3.580753	0.01	0.00
145	50.408492	-3.580752	0.01	0.00
150	50.408492	-3.580752	0.00	0.01
155	50.408491	-3.580752	0.01	0.01
160	50.408492	-3.580752	0.02	0.00
165	50.408492	-3.580752	-0.03	-0.02
170	50.408492	-3.580752	-0.01	0.00
175	50.408491	-3.580753	0.02	-0.01

If you implement closed-loop correction of the DR solution instead of open-loop correction, you will get a slightly different solution:

Time (s)	Latitude (°)	Longitude (°)	Velocity (m/s) North	East
0	50.424958	-3.595797	-0.05	10.03
0.5	50.424948	-3.595737	0.01	10.01
1	50.424943	-3.595669	0.00	10.00
1.5	50.424941	-3.595599	-0.03	10.02
2	50.424939	-3.595528	-0.02	10.01
2.5	50.424939	-3.595458	0.00	10.03
3	50.424939	-3.595388	-0.02	10.01
3.5	50.424938	-3.595318	-0.01	10.01
4	50.424938	-3.595248	-0.01	10.01
4.5	50.424938	-3.595178	0.02	10.00
5	50.424938	-3.595108	-0.01	10.01
10	50.424937	-3.594406	-0.04	10.00
15	50.424937	-3.593527	0.04	15.00
20	50.424937	-3.592294	0.02	20.01
25	50.424939	-3.590884	-0.01	20.02
30	50.424937	-3.589474	-0.03	20.01
35	50.424934	-3.588241	0.00	14.99
40	50.424933	-3.587361	0.00	10.01
45	50.424485	-3.587221	-13.37	0.00
50	50.423772	-3.587224	-18.31	0.00
55	50.422884	-3.587222	-19.99	-0.01
60	50.421984	-3.587222	-20.00	0.00
65	50.421094	-3.587063	-18.91	6.52

Time (s)	Latitude (°)	Longitude (°)	Velocity (m/s) North	East
70	50.420301	-3.586401	-17.35	10.00
75	50.419522	-3.585695	-17.34	10.00
80	50.418706	-3.584956	-19.96	11.53
85	50.417710	-3.584055	-24.33	14.05
90	50.416555	-3.583011	-26.02	15.01
95	50.415386	-3.581955	-26.01	15.01
100	50.414165	-3.581080	-29.29	6.53
105	50.412819	-3.580987	-30.02	-0.01
110	50.411469	-3.580987	-30.01	0.03
115	50.410177	-3.580989	-25.38	0.01
120	50.409224	-3.580988	-17.03	0.02
125	50.408646	-3.580989	-8.67	0.01
130	50.408466	-3.580844	-0.02	3.87
135	50.408468	-3.580739	-0.02	-0.01
140	50.408470	-3.580740	0.01	0.00
145	50.408471	-3.580741	0.01	0.00
150	50.408473	-3.580742	0.00	0.01
155	50.408474	-3.580743	0.01	0.01
160	50.408476	-3.580743	0.02	0.00
165	50.408477	-3.580744	-0.03	-0.02
170	50.408479	-3.580745	-0.01	0.00
175	50.408479	-3.580746	0.02	-0.01

Task 3: UAV INS/GNSS Integration

The position, velocity and attitude solution is as follows:

Time (s)	Latitude (°)	Longitude (°)	Height (m)	Velocity (m/s) North	East	Down	Attitude (°) Roll	Pitch	Heading
0	-2.575939	-67.417578	997.6	-0.01	199.97	0.07	0.28	-0.06	91.00
1	-2.575941	-67.415785	997.9	0.00	200.02	0.01	0.09	-0.19	90.99
2	-2.575943	-67.413988	998.1	0.01	200.03	-0.01	0.06	-0.09	90.99
3	-2.575945	-67.412191	998.0	0.00	200.02	0.00	0.09	-0.01	90.98
4	-2.575946	-67.410394	997.9	0.01	200.00	0.00	0.08	0.04	90.98
5	-2.575947	-67.408597	997.9	0.00	199.99	0.00	0.08	0.05	90.98
6	-2.575947	-67.406799	997.9	0.01	199.99	0.00	0.08	0.04	90.97
7	-2.575947	-67.405002	997.9	0.00	200.00	-0.01	0.08	0.05	90.97
8	-2.575947	-67.403204	997.9	0.00	200.00	-0.01	0.08	0.05	90.97
9	-2.575948	-67.401407	997.9	0.00	200.00	-0.01	0.09	0.05	90.98
10	-2.575948	-67.399609	997.9	0.00	200.00	0.00	0.08	0.06	90.98
20	-2.575949	-67.381628	998.2	0.02	199.99	-0.02	0.07	0.06	90.95
30	-2.577029	-67.363693	998.5	-24.16	198.55	-0.02	14.11	0.06	96.94
40	-2.580308	-67.346023	998.6	-48.28	194.08	-0.02	14.12	0.04	103.94
50	-2.585736	-67.328884	998.9	-71.65	186.71	-0.03	14.12	-0.03	111.09

Time	Latitude	Longitude	Height	Velocity (m/s)			Attitude (°)		
(s)	(°)	(°)	(m)	North	East	Down	Roll	Pitch	Heading
60	-2.593231	-67.312535	998.7	-93.97	176.61	0.01	14.10	0.01	118.05
70	-2.602682	-67.297219	998.9	-114.83	163.76	-0.02	14.08	0.05	125.06
80	-2.613945	-67.283166	998.8	-133.99	148.48	0.00	14.09	0.07	132.06
90	-2.626594	-67.270317	998.7	-141.41	141.43	0.01	0.05	0.09	134.98
100	-2.639381	-67.257601	998.8	-141.40	141.43	-0.02	0.04	0.09	135.02
110	-2.652168	-67.244884	998.8	-141.42	141.41	-0.02	0.03	0.08	135.04
120	-2.664704	-67.231930	998.8	-131.40	150.79	0.00	-14.03	0.08	131.14
130	-2.675720	-67.217682	998.9	-111.95	165.74	0.00	-14.03	0.07	124.12
140	-2.684901	-67.202200	999.0	-90.85	178.16	-0.02	-14.05	0.06	117.11
150	-2.692108	-67.185720	998.9	-68.38	187.92	-0.02	-14.06	0.04	110.06
160	-2.697235	-67.168488	998.6	-44.88	194.87	-0.01	-14.09	0.02	103.01
170	-2.700202	-67.150760	998.6	-20.71	198.93	-0.01	-14.11	0.00	95.99
180	-2.700994	-67.132805	998.6	0.00	200.03	0.02	-0.05	0.05	90.19