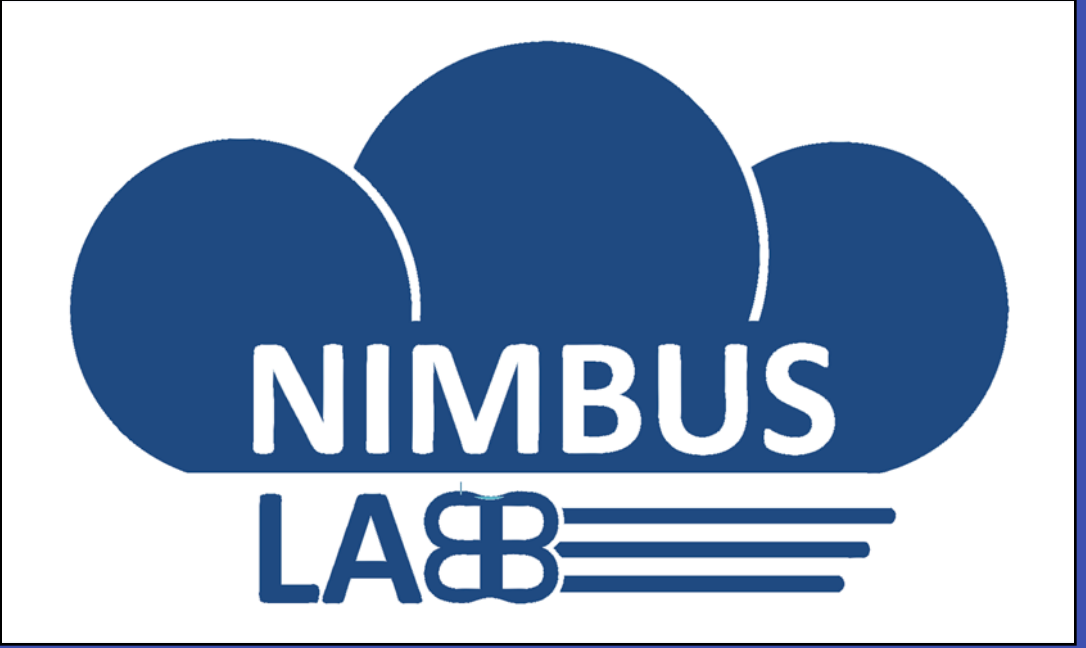# On-Demand vs Post-Processed Displacement Measurements of Bridge Deformations

Mohamed Aly[a], Chungwook Sim[b,*], Carrick Detweiler[a]

[a] School of Computing, College of Engineering, University of Nebraska - Lincoln
[b] Department of Civil and Environmental Engineering, College of Engineering, University of Nebraska - Lincoln

Summary

- Serviceability and health of bridges are reflected through structures deformations

- Measuring bridge deformation displacements provide a powerful diagnostic tool

- Many researches have placed targets to post-process displacements

- This project aims to utilize CV algorithms to track deformations with no targets

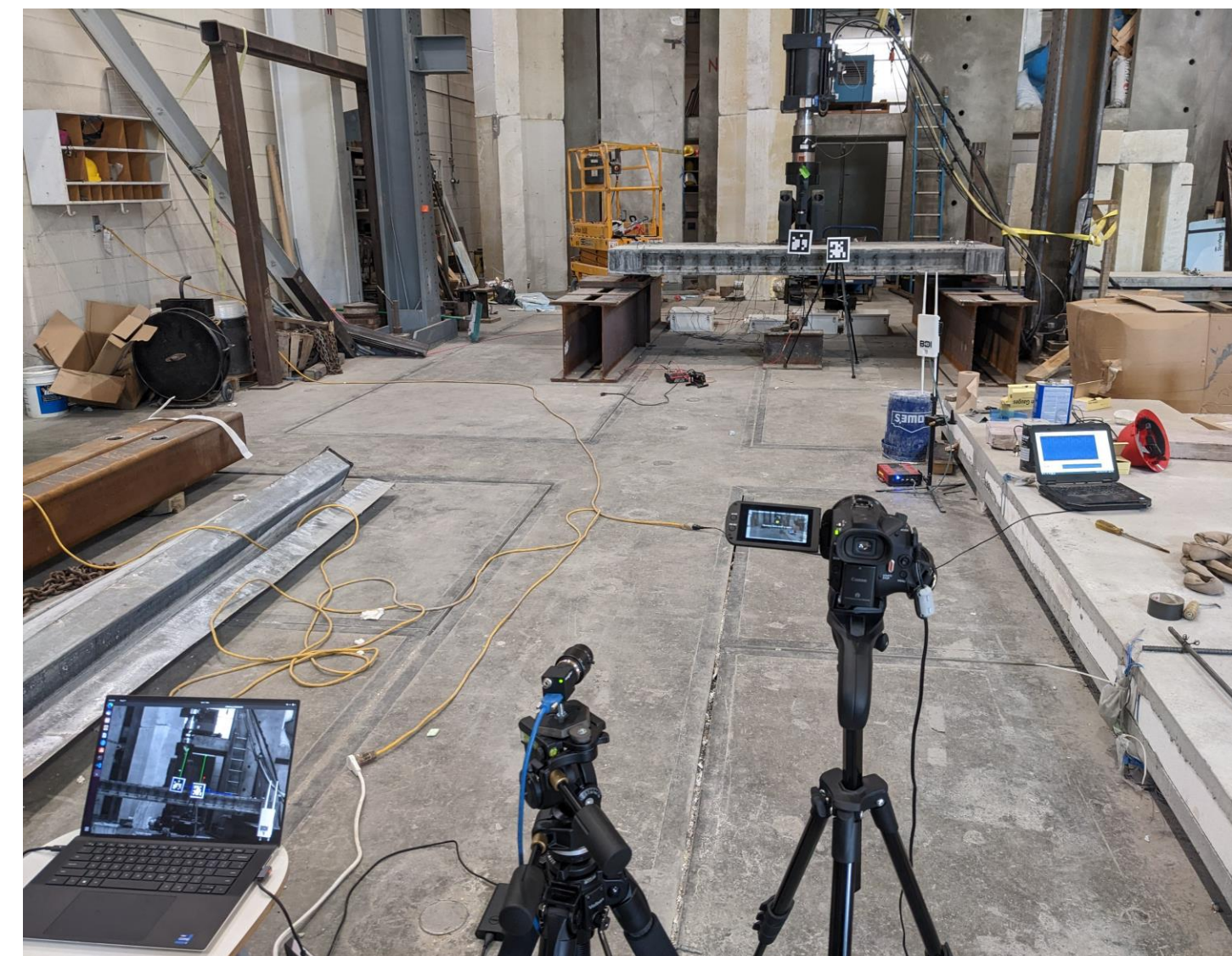- This work shows on-demand vs post-processed measurements using ArUco tags

Datasets

- Collected at different distances while running Dynamic and Static Fatigue Tests on specimens

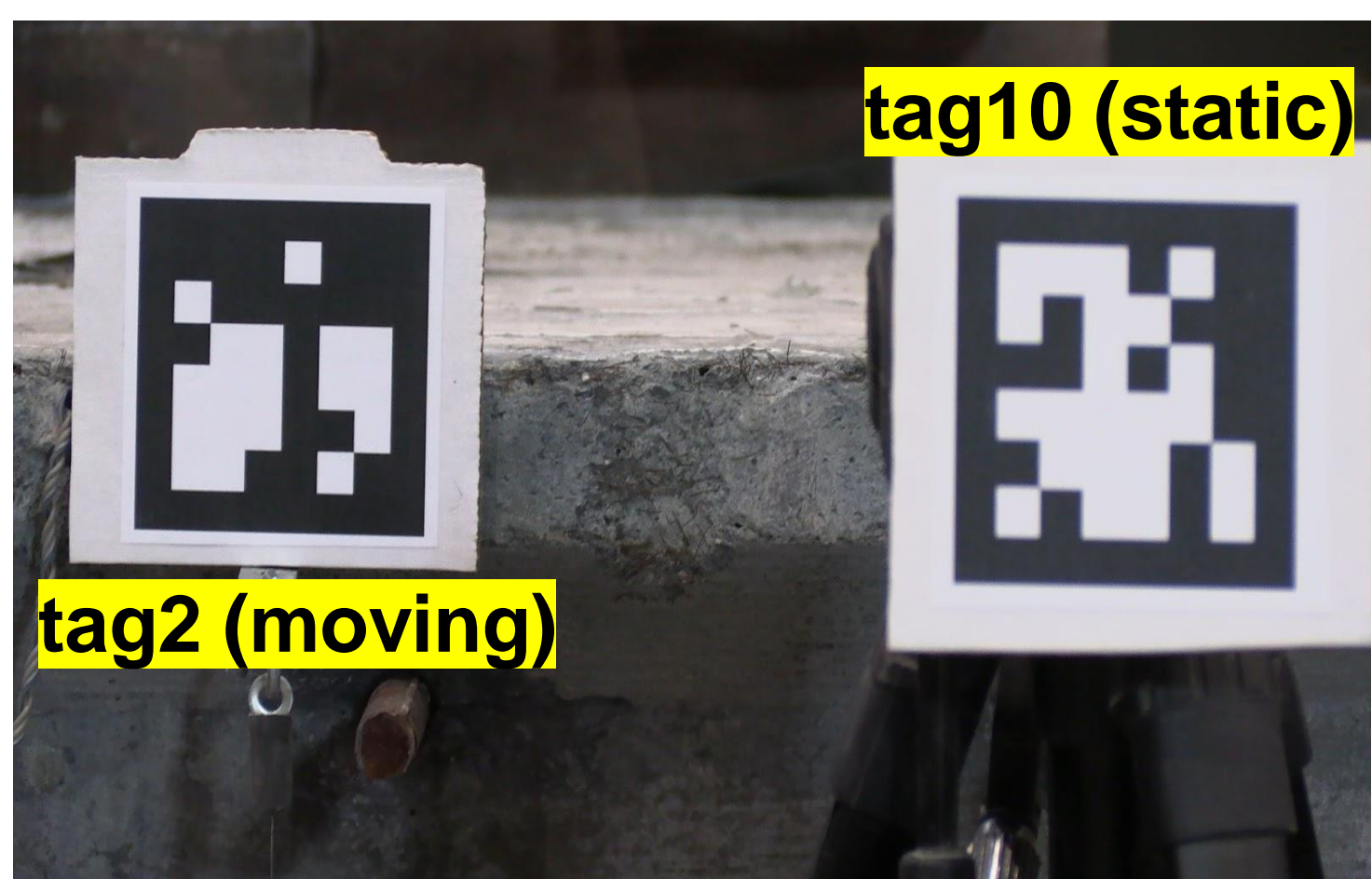- Compared to attached potentiometer data as the ground truth
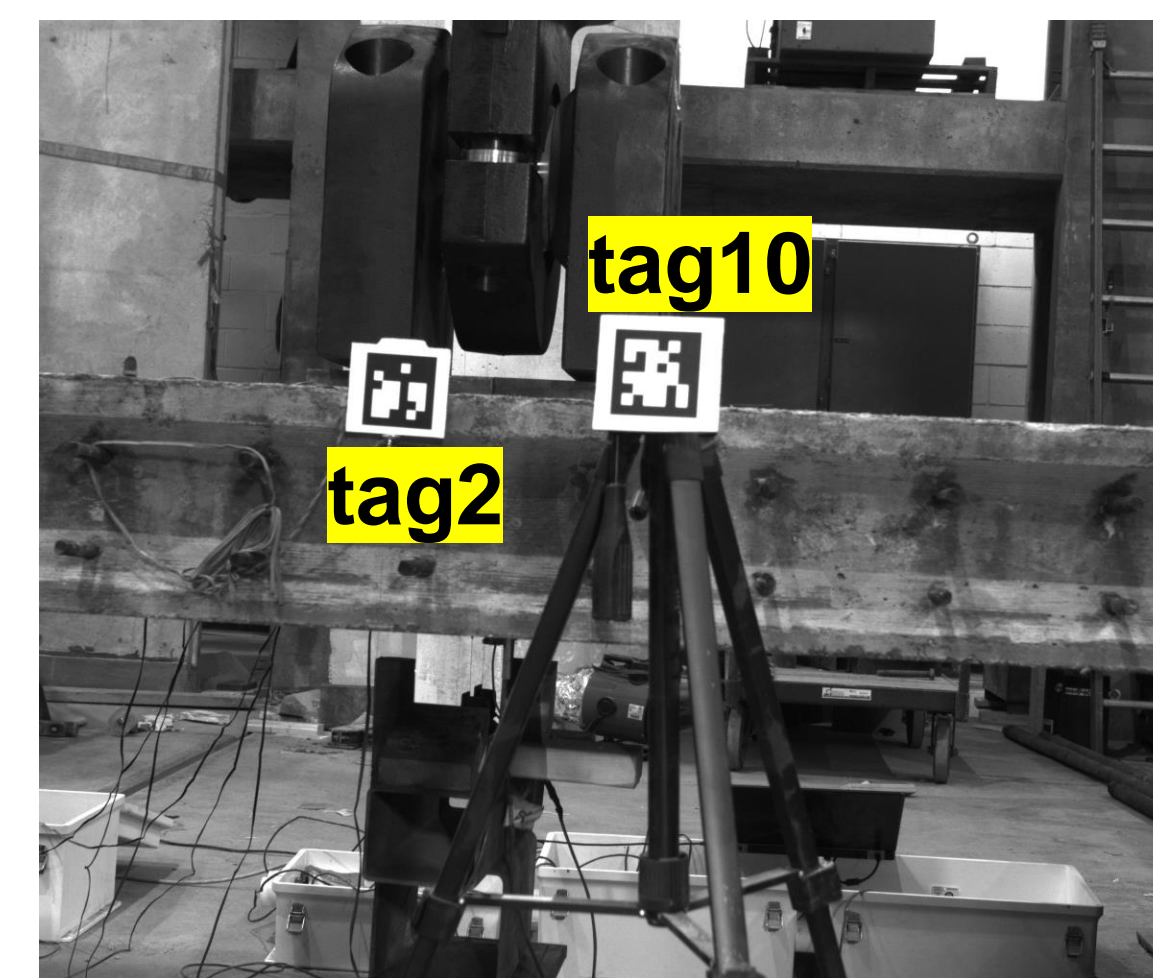

Setup for 5F9 Test

Setup for 25F Test

Video Cam picture for 5F9 Test

FLIR Cam picture for 5F9 Test

Video Cam picture for 25F Test

FLIR Cam picture for 25F Test

Analysis

5F9 Test Dataset (400 seconds)

	tag	top_left_coord_y	displacement_pixel	displacement_inch
0	2	446.716	23.272	0.0709
1	2	446.716	23.272	0.0709
2	2	446.716	23.272	0.0709
3	2	446.716	23.272	0.0709
4	2	446.716	23.272	0.0709
...	...	...	...	...
11995	2	467.839	2.149	0.0065
11996	2	468.733	1.255	0.0038
11997	2	469.210	0.778	0.0024
11998	2	468.779	1.209	0.0037
11999	2	467.754	2.234	0.0068

12000 rows × 4 columns

25F Test Dataset (422 seconds)

	tag	top_left_coord_y	displacement_pixel	displacement_inch
0	2	784.613	1.417	0.1379
1	2	784.613	1.417	0.1379
2	2	784.613	1.417	0.1379
3	2	784.613	1.417	0.1379
4	2	784.613	1.417	0.1379
...	...	...	...	...
12655	2	784.662	1.368	0.1331
12656	2	784.735	1.295	0.1260
12657	2	784.766	1.264	0.1230
12658	2	784.731	1.299	0.1264
12659	2	784.628	1.402	0.1364

12660 rows × 4 columns

Potentiometer (Ground Truth) Analysis

	Time	SP50120287_20A	Diff
count	20000.0000	20000.0000	20000.0000
mean	200.0100	18.2887	0.0523
std	115.4729	0.0364	0.0364
min	0.0200	18.2394	0.0001
25%	100.0150	18.2523	0.0140
50%	200.0100	18.2874	0.0536
75%	300.0050	18.3270	0.0887
max	400.0000	18.3409	0.1016
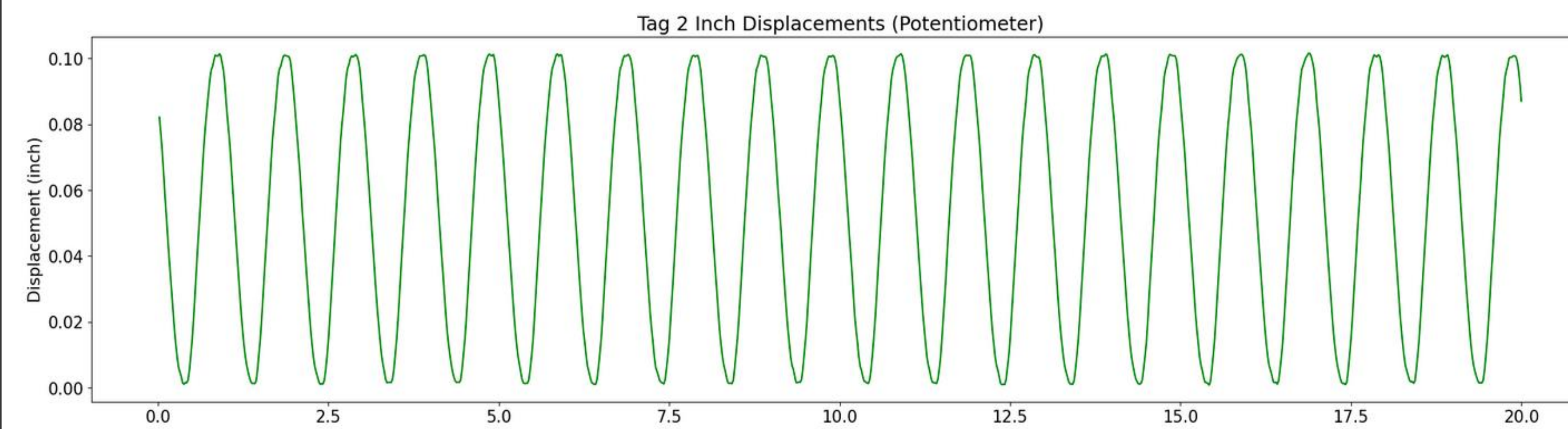
Tag 2 Inch Displacements (Potentiometer)

5F9 Test Video Cam (Post-Processed) Analysis

	In real life (inches)	In image (pixels)
Tag2 size	2.5	820.7442
Displacement	0.1	32.8298

	tag	top_left_coord_y	displacement_pixel	displacement_inch
count	12000.0	12000.0000	12000.0000	12000.0000
mean	2.0	452.6668	17.3212	0.0528
std	0.0	12.2267	12.2267	0.0372
min	2.0	434.3490	0.0000	0.0000
25%	2.0	440.3428	5.1260	0.0156
50%	2.0	453.2340	16.7540	0.0510
75%	2.0	464.8620	29.6452	0.0903
max	2.0	469.9880	35.6390	0.1086

5F9 Test Tag 2 Inch Displacements (Video Cam)

25F Test Video Cam (Post-Processed) Analysis

	In real life (inches)	In image (pixels)
Tag2 size	6.5	66.8129
Displacement	0.1	1.0279
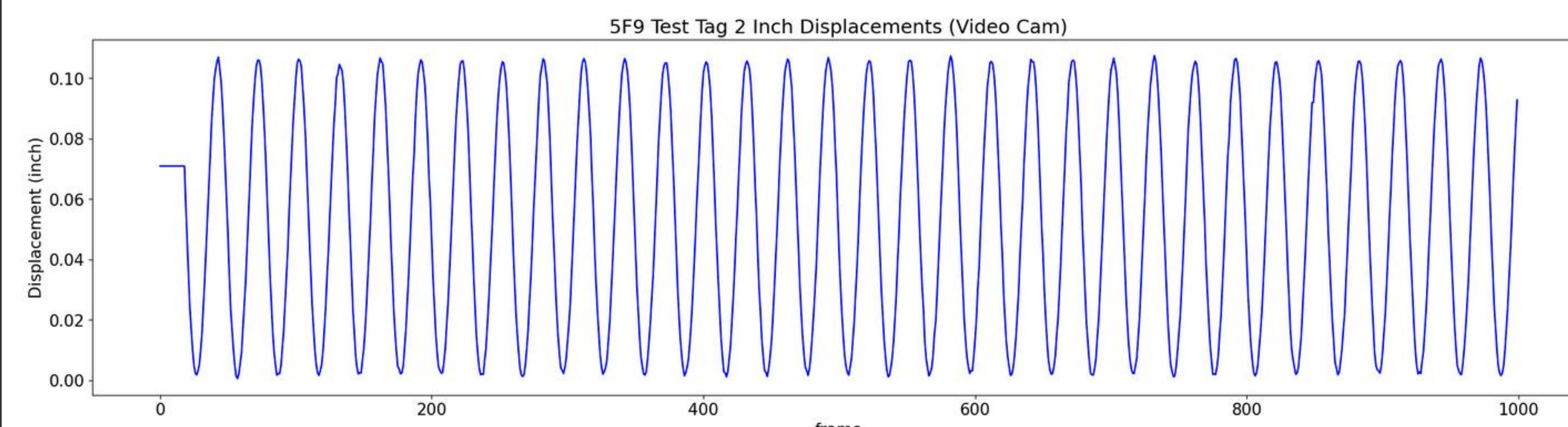
	tag	top_left_coord_y	displacement_pixel	displacement_inch
count	12660.0	12660.0000	12660.0000	12660.0000
mean	2.0	785.1459	0.8841	0.0860
std	0.0	0.6462	0.6462	0.0629
min	2.0	783.7360	-2.0000	-0.1946
25%	2.0	784.7140	0.5550	0.0540
50%	2.0	785.0000	1.0300	0.1002
75%	2.0	785.4750	1.3160	0.1280
max	2.0	788.0300	2.2940	0.2232

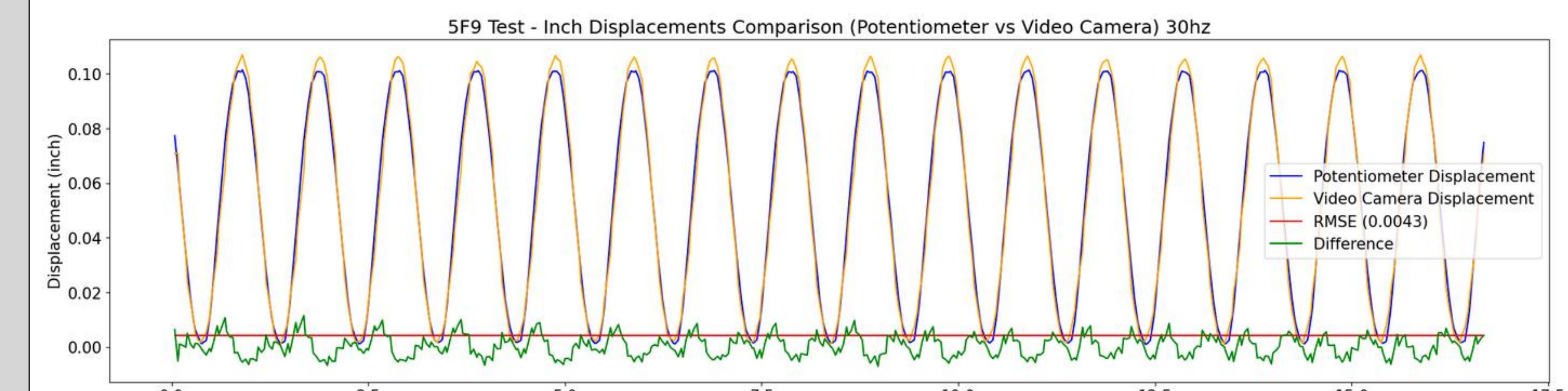25F Test - Tag 2 Inch Displacements (Video Cam)
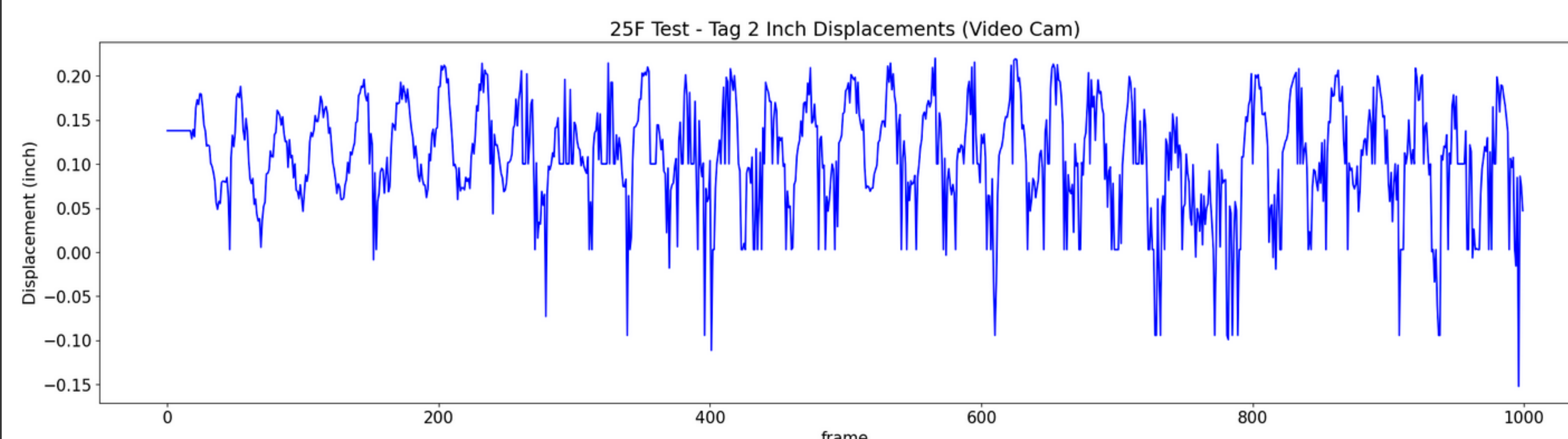
Post-processed Deformation Measurements

5F9 Test Video Cam (Post-Processed) Analysis

	Diff: Potentiometer Displacements (inch) - Video Camera Displacements (inch)
RMSE	0.0043
mean	-0.0004
std	-0.0042
min	-0.0107
25%	-0.0038
50%	-0.0007
75%	0.0025
max	0.0128
Range	0.0235

	Time	potentio_diff	vidcam_diff	rmse	diff
0	0.04	0.0773	0.0709	0.0043	0.0064
1	0.08	0.0657	0.0709	0.0043	-0.0052
2	0.10	0.0589	0.0578	0.0043	0.0011
3	0.14	0.0465	0.0459	0.0043	0.0006
4	0.18	0.0345	0.0346	0.0043	-0.0001
...	...	...	...	...	...
495	16.54	0.0277	0.0286	0.0043	-0.0010
496	16.58	0.0413	0.0370	0.0043	0.0043
497	16.60	0.0483	0.0472	0.0043	0.0011
498	16.64	0.0625	0.0595	0.0043	0.0030
499	16.68	0.0748	0.0706	0.0043	0.0042

500 rows × 5 columns

5F9 Test - Inch Displacements Comparison (Potentiometer vs Video Camera) 30hz

25F Test Cam Video Analysis

25F Test - Inch Displacements Comparison (Potentiometer vs Video Camera) 30hz
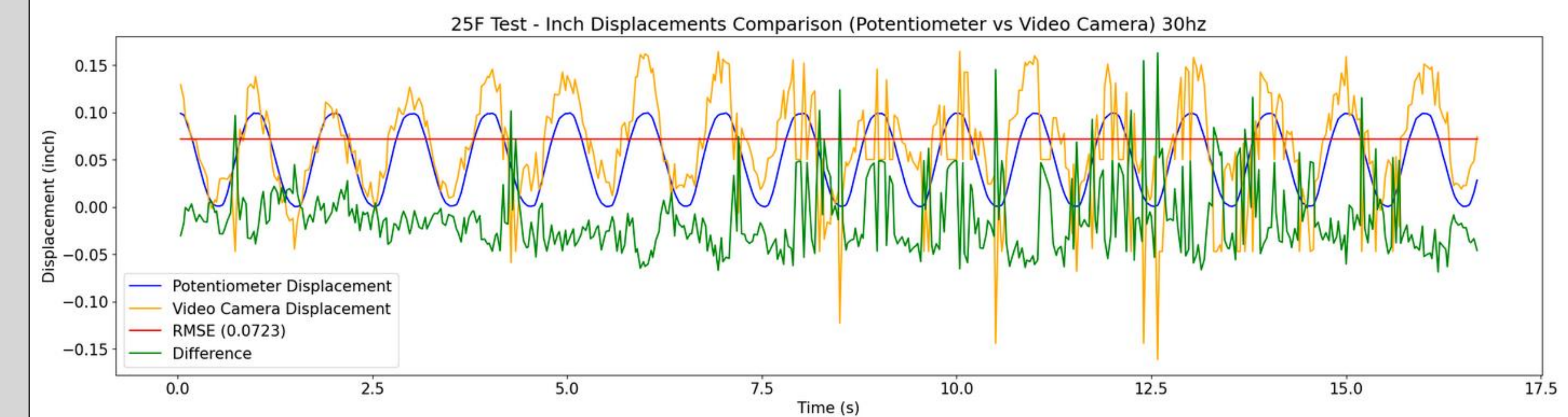
Online Deformation Measurements

5F9 Test - Inch Displacements Comparison (Potentiometer vs Flir Camera) 26hz

25F Test - Inch Displacements Comparison (Potentiometer vs Flir Camera) 26hz
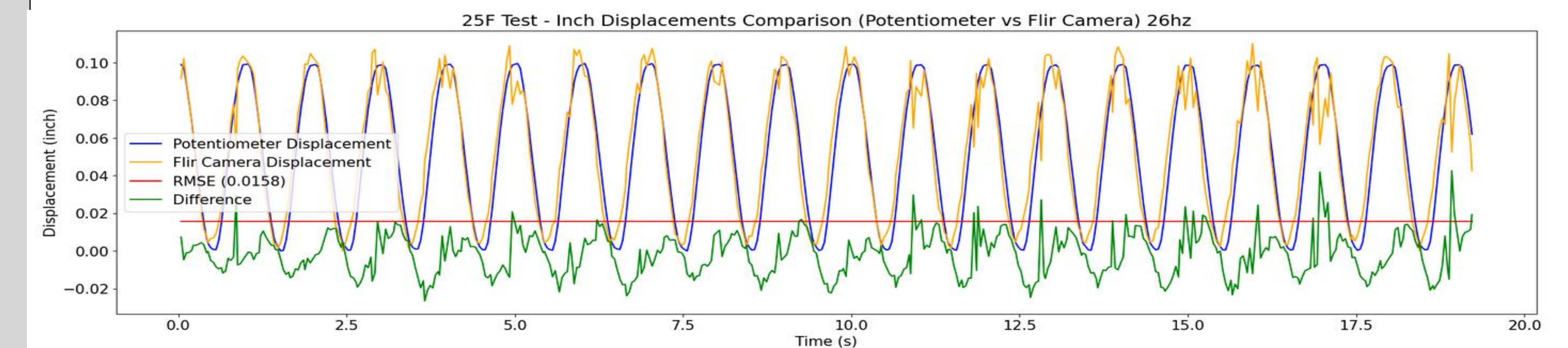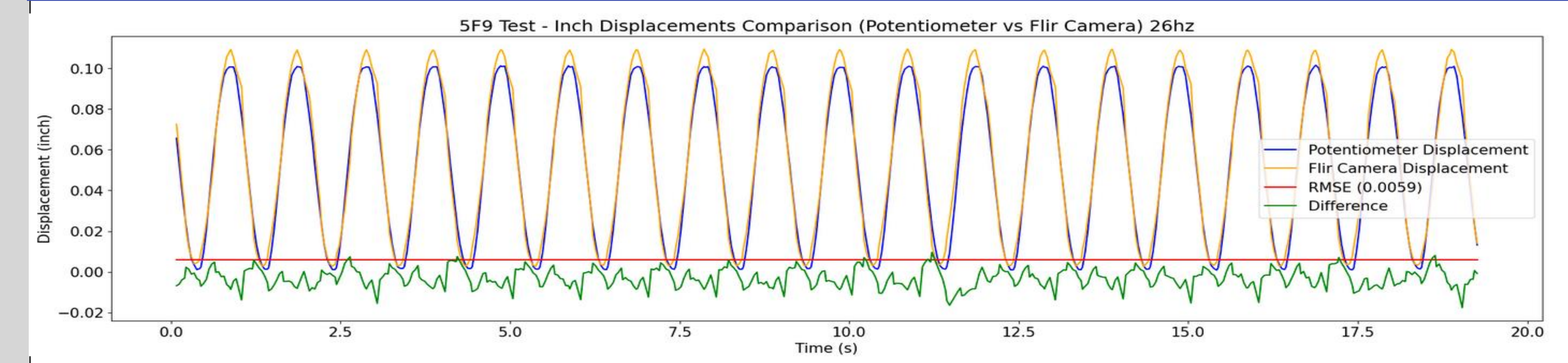
Conclusion

- Online measurements performed better than post-processed videos in Far Test

- Autofocusing and not zooming enough result inaccurate displacement measurements.

Challenges:

Blurriness – start time syncing – 29.97 frame rate for video camera