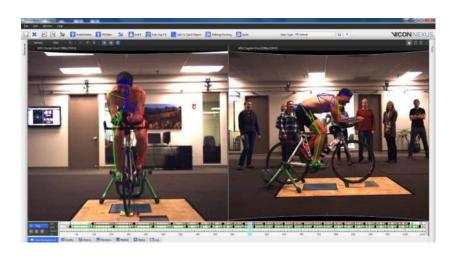
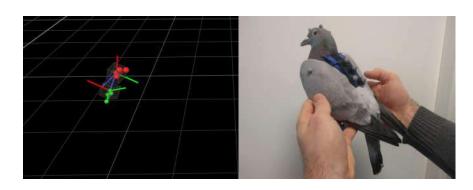
Introduction VICON

Hemal Naik

Features

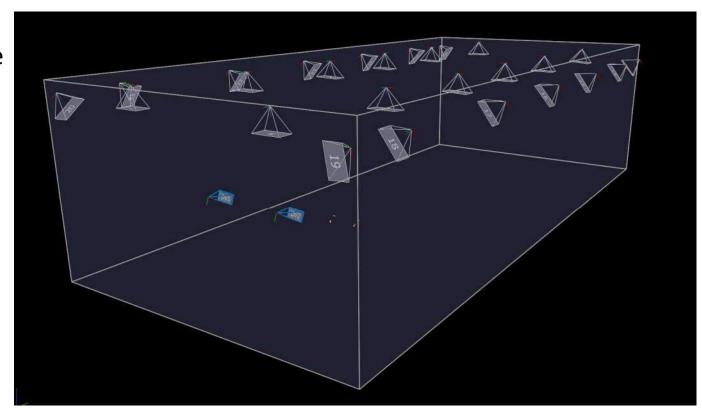
- Hardware
 - 30 Infrared Cameras Up to 300 Hz
 - 6 Video Cameras 60 Hz @ 1080p, 120Hz @ 720p
- Software
 - Nexus Skeleton tracking and motion capture + Video
 - Tracker Object tracking (patterns with 4 or more points)
 - Undistortion tool Video undistortion tool.





Configuration

- Placement Configuration
 - 30 IR cameras roof mounted
 - 4 Video roof mounted
 - 2 Video cameras flexible placement



Calibration Process

- One process for Video and IR cameras
- Calibration object (Wand from VICON)
- Custom objects possible
- Process : Approx 20-30 Mins
- Quality: World Error in 3D (mm), Image Error in 2D (pix)
- Output .xcp file.
 - Intrinsic and Extrinsic information of cameras.
 - Video distortion parameters, not OpenCV format, math available.

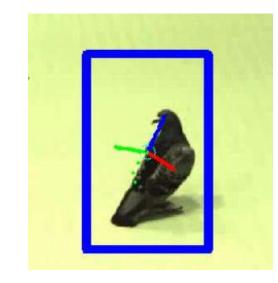
Example File

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<
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    <Capture END TEMP="57" END TIME="2018-08-20 14:37:37.277" START TEMP="54" START TIME="2018-08-20 14:27:36.853"/>
    <ControlFrames/>
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     FRINCIPAL POINT="962.810119628906 506.493713378906" VICON RADIAL2="Vicon3Parameter 962.81012466661423 506.49370228508934 3.4408334717032025e-008 -1.549242704035403e-015 4.4000537109732894e-021" WORLD ERROR="0.793358714741043"/>
    </KevFrames>
  </camera>
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    </ReyFrames>
  </Camera>
```

Measurements: Object

- Object Defined in either software as pattern of 4 Markers
- Each object has its own coordinate system.
- 4 Markers p1,p2,p3,p4
- X Axis : (Vector (p1p2)
- Y Axis : Cross (Vector (p1p2), Vector(p1p3))
- Z Axis : Cross (X- Axis,Y- Axis)
- .mp file : 3D position in object space
- **Caution**: Object name must start from letters, if started from numbers .mp file does not store positions.
- Objects can be 2D or 3D, upto 100 or more can be supported by VICON*.



Measurements: Unlabelled Points

- Points that are not part of pattern or skeleton are called unlabelled.
- Each marker position is measured, triangulated and stored by VICON system.
- Trajectory is maintained if possible (depending on settings).

Measurement: Skeleton

- Only Nexus supports skeleton
- Custom skeleton can be defined with markers
- Human skeleton has multiple support plugins
- Tutorials on vicon website
- Joint positions and Angles as output
- Automatic annotation with video possible if tracking of all markers is successful



Session recording for offline use

- Each software can record a session in which all marker positions are recorded and stored.
- .x2d and .x3d format
- Both Nexus and Tracker can access .x2d, process the trial.
- Settings related to traingulation can be changed, but not related to capture.
- Objects can be defined, modified and reprocessed offline.

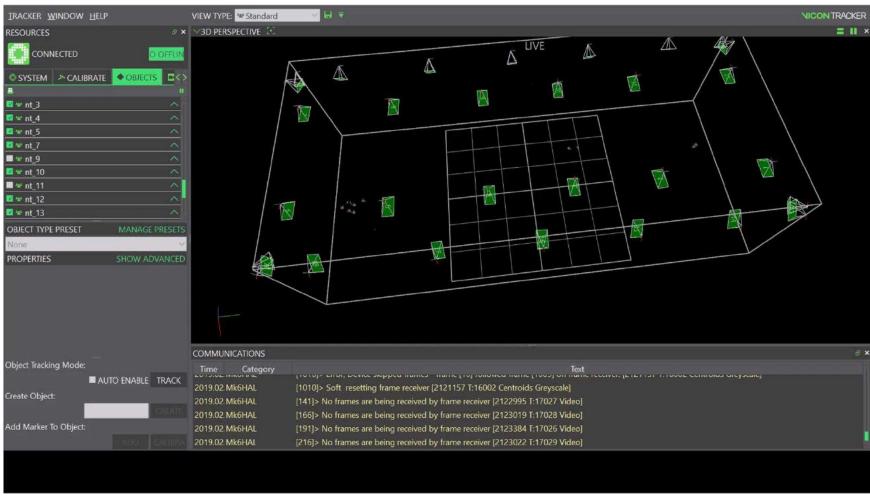
Real-Time communication - online

- Tracking information can be accessed realtime.
 - Over UDP Tracker Software
 - DataStream API (C++) Tracker, Nexus
- Datastream contains both labelled and unlabelled measurements.
- C++ based application can be developed for reading stream and 2D point detections from each image. (Example code available).
- Realtime stream grab can lower measurement FPS depending on processing and storing speed.
- Hardware connection is required.

Tracker Software

- Specialised for tracking Objects (patterns).
- Visualization : object as a coordinate system, triangulation etc.
- Output in .csv format
- Output 1: 6DOF pose of objects with Frame ID
 - Format : Frame Object 1 (R,T) Object 2 (R,T)
- Output 2 : Unlabelled Trajectories
 - 3D (x,y,z) Trajectories of points (Rows = frames)
 - Points in same columns represent same point.
 - If tracking is lost, same point gets new column.
 - Each detected 3D point in put in a column.
 - Format: Frame, Point 1 (x,y,z), Point 2(x,y,z), Point 3 (x,y,z) ...

Layout



Typical Output : Labelled

Objects 100																
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rame	Sub Frame	KX	RY	RZ	RW	TX	TY	TZ	RX	RY	RZ	RW	TX	TY	TZ	
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1	0		0.080238			-205.87			0.03953		0.873896					
2	0			0.886669		-210.69				0.218612						
3	0	12-14-14-14-14-14-14-14-14-14-14-14-14-14-	0.07823	0.88364	-0.3683	-215.553				0.218398			200000000000000000000000000000000000000			
4	0		0.069391		-0.3569	-219.896			0.048144		0.876575					
5	0		0.081549		-0.35538	-223.061				0.204429				-2063.8		
6	0		0.103242			-226.444				0.201713						
7	0		0.132549			-229.635				0.186811				-2062.6		
8	0		0.149451		-0.35253	-233.286				0.188116						
9	0	-0.2222	0.154268	0.898627	-0.3454	-236.825		166.337	0.056828	0.198378	0.860234	0.466276	-308.419	-2058.53	177.314	
10	0		0.174615			-239.76		167.978	-0.00445					-2048.44		
11	0	-0.14041	0.179773	0.910372	-0.34524	-242.197	-2038.62	168.573	0.013522	-0.10728	0.584791	-0.80395	-313.589	-2043.67	188.82	
12	0	-0.09104	0.181131	0.919404	-0.33705	-244.172	-2035.78	168.04	0.008271	-0.10354	0.609338	-0.78608	-320.337	-2039.47	194.631	
13	0	-0.05402	0.267886	0.894021	-0.35503	-246.295	-2034.22	167.076	0.018226	-0.09567	0.61768	-0.78038	-325.953	-2035.37	198.897	
14	0	-0.02741	0.275655	0.893626	-0.35312	-248.494	-2033.47	166.868	0.038041	-0.10324	0.618734	-0.77786	-330.469	-2032.12	201.128	
15	0	-0.01728	0.279327	0.89384	-0.35033	-251.011	-2034.53	167.193	0.06333	-0.09607	0.619106	-0.77683	-333.839	-2030.95	203.37	
16	0	-0.00816	0.293137	0.889391	-0.3507	-253.432	-2036.2	167.312	0.054927	-0.09969	0.61296	-0.78187	-335.342	-2030.35	204.599	
17	0	-0.00093	0.27982	0.896835	-0.34262	-256.126	-2038.56	167.639	0.056207	-0.09532	0.615502	-0.78033	-335.603	-2030.84	205.52	
18	0	0.005404	0.264042	0.904626	-0.33452	-258.698	-2041.27	167.61	0.059185	-0.0947	0.603739	-0.78932	-335.385	-2031.59	205.791	
19	0	0.008498	0.222078	0.920351	-0.32181	-261.542	-2044.92	167.086	0.059138	-0.09832	0.610503	-0.78366	-335.041	-2032.07	206.02	
20	0	0.00549	0.210322	0.922799	-0.32276	-264.7	-2048.96	166.127	0.03646	-0.09366	0.622484	-0.77615	-334.346	-2032.87	206.569	
21	0	0.004097	0.177443	0.932516	-0.3145	-268.23	-2053.3	164.813	0.03958	-0.10467	0.626477	-0.77137	-334.245	-2033.58	206.578	
22	0	0.003921	0.073976	0.960111	-0.26963	-271.72	-2057.66	163.51	0.058436	-0.10048	0.6216	-0.77466	-334.09	-2034.32	206.572	
23	0	0.001404	0.069662	0.962991	-0.26037	-275.35	-2061.31	161.886	0.067651	-0.10109	0.622001	-0.77351	-333.809	-2035.02	206.786	
24	0	0.001762	0.056427	0.966747	-0.24943	-278.906	-2064.5	160.333	0.070426	-0.10657	0.622076	-0.77247	-333.848	-2035.78	206.736	
25	0	-0.00359	0.052583	0.970245	-0.23632	-282.405	-2066.84	159.203	0.059127	-0.1122	0.625011	-0.77025	-334.282	-2036.69	206.527	
26	0	0.000744	0.055548	0.971591	-0.23005	-285.918	-2068.6	158.688	0.059073	-0.11868	0.625022	-0.76927	-335.254	-2037.77	207.246	
27	0	0.004	0.048645	0.9746	-0.21857	-289.069	-2069.79	158.326	0.057353	-0.12539	0.628834	-0.76522	-338.289	-2038.99	208.881	
28	0	0.010927	0.039884	0.976334	-0.21228	-292.023	-2070.67	158,328	0.074017	-0.13623	0.647829	-0.74584	-343,893	-2040.2	212.504	

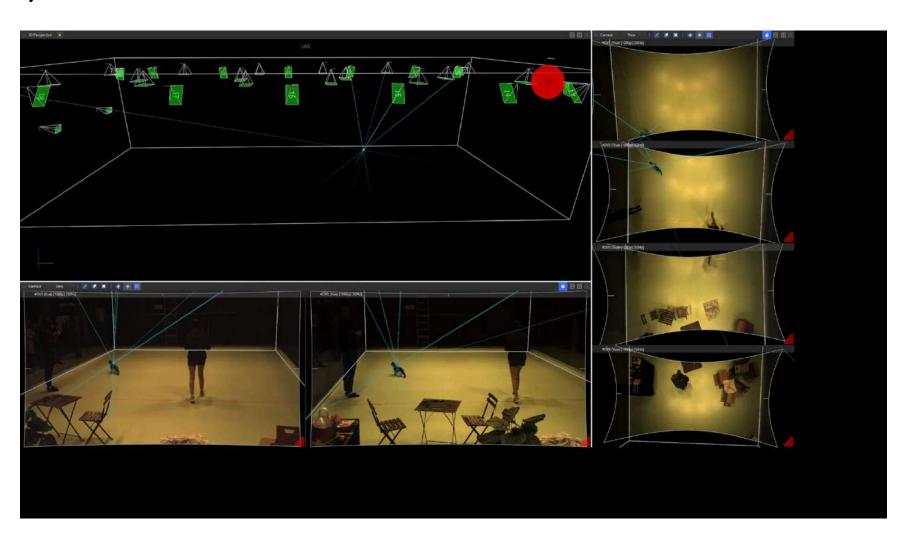
Output : Unlabelled

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1		-110.12													-1082.6 1			-1055 1				1407.06																		
2	0	-110.08													-1083 1 1						-1059.3	1407.51																		
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4				1353.78											-1084.1 1							1407.59																		
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6	0 .			1353.35											-1085 1							1407.82																		
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27	.0 -	-107.88	1521.8	1344.51	-118.73	-1460.7	1390.44	-130.57	+1476.7	1381.21	-81.758	-1588.2	1329.72	-362.32	-1100.9 1	416.43	-393.2	-1073.1 1	390.32	-363.34	-1076.2	1412.36																		
28	0 -	-107.67	1522.4	1343.46	-119.17	-1461.2	1389.19	-130.89	-1477.3	1379.93	-81.478	-1533.6	1329.04	-363.96	-1102.1 1	417.14	-594.63	-1074.7	1390.8	-364.92	-1077.6	1412.87																		
29	0 -	-107.55	-1523	1842.31	-119.61	-1461.6	1387.8	-131.14	-1477.8	1378.42	-81.092	-1534.2	1328.25	-365.95	-1103.6 1	417.83	-396.32	-1076.2 1	391.38	-365.88	-1079	1412.91																		
30	0 -	-107.24 -	1523.6	1341	-120.01	-1462.2	1386.23	-131.45	+1478.5	1376.75	-80.62	-1534.8	1327.27	-368.11	-1105.2 1	418.66	-398.43	-1077.5 1	592.04	-367.96	-1080.7	1413.73 -	346.18	-1126.2	1439.25	5														
31	0 -	-106.86	1524.4	1339.64	-120.56	-1462.9	1384.57	-131.64	-1479.1	1374.85	-79.94	-1535.5	1326.3	-370.42	-1106.8 1	419.42	-400.77	-1079.2 1	392.94	-370.86	-1082.6	1415.05	-348.4	-1128.1	1439.91															
32	0	106.25	1525.2	1338.06	-120.83	-1463.7	1382.43	-131.88	-1480	1372.74	-79.093	-1536.4	1325.27	-373.33	-11088 1	420.96	-403.28	-1081.1 1	393.86	-873.24	-1084.2	1415.71	350.93	-1130.1	1440.71	-331.87	-1124.8	1453.1	2											
33	0	105.47	1526.3	1336.4	-121.25	1464.7	1380.38	-131.99	-1481.2	1370.37	-78.052	-1537.3	1324.07	-376.06	-1110.7 1	421.61	-404.35	-1083.1 1	393.11	-375.37	-1086.3	1416.2	353.88	-1132.4	1441.73	3 -334.79	-1126.5	1454.0	8											
34	0	104.58	1527.5	1534.47	-121.4	-1465.8	1377.87	-131.96	-1482.3	1367.74	-76.766	-1538.5	1322.87	379.28	-1113 1	422.58	408.71	-1085.2 1	395.33	-379.23	<1088.7	1417.72 -	357.26	-1134.8	1442.8	337.8	-1129.4	1454.8	5											
35	0	103.58																				1418.47																		
36	0 -	102.02	1530.6	1330.23	-121.43	-1468.7	1372.33	-131.22	-1485.5	1362.09	-73.453	-1541.3	1320.21	-385.47	-1118.2 1	424.42	415.53	-1090 1	396.82	-385.81	-1093.8	1419.09	364.67	-1140	1444.59	-345.43	-1134.8	1456.9	9											
37	0 -																					1419.93					-1137.5													
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49																						1413.75 "																		
50																						1412.19																		
51																						1410.67 "																		
52	0			1311.19																		1408.86																		
53	0			1313.48			1340.72															1406.59																		
54	0 -																					1404.42																		
55	0 -																					1402.08 -					-1243		7.5											
56																						1399.41																		
57																						1396.76 -																		
58	0 -	-21.665 -	-1607.8	1533.84	-79.204	-1562	1357,07	-76,652	-1581.3	1346.82	10.2205	-1604.4	1335.9	-513.43	-1240.2 1	395.69	-531.23	-1205.6 1	365.66	-508.68	-1215.6	1393.64	-499.7	-1266.6	1417.46	-483.57	-1265,2	1434.3	5											

Nexus Software

- Specialised for Skeleton tracking, Mocap, Video analysis of movement and simplified annotation etc.
- Lots of features, Customized Python-Matlab code can be written for specific objectives.
- Video view Augmented with tracking information.
- Export of Videos (.vvid format .avi format)
- 3D Visualisation: Trajectory, Point, Trinagulation

Layout



Example Output: 3D Positions, Joint angles etc.

rajectorie	s																								
100																									
		head:he	adPattern1		head:he	eadPattern2		head:headPattern3			head:headPattern4			backpack:backpack1			backpack:	backpack2		backpack:backpack3			backpack:	ackpack4	
rame	Sub Fram	ne X	Υ	Z	X	Y	Z	X	Y	Z	X	Y	Z	Х	Y	Z	X	Υ	Z	X	Y	Z	X	Y	Z
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1		0												-220.563	-2053.54	136.428	-183.009	-2026.17	144.865	-217.404	-2034.96	140.476	-202.56	-2049.91	139.37
2		0												-225.363	-2056.39	137.796	-187.854	-2030.02	146,733	-222.182	-2038.04	141.805	-207.492	-2052.63	140.15
3		0												-230,242	-2058.99	140.048	-192.715	-2031.97	149.394	-226.997	-2040.37	143.969	-212.409	-2054.92	142.51
4		0												-234.727	-2060.49	142.141	-196.714	-2034.23	152.299	-231.129	-2041.85	146.298	-216.701	-2056.4	144.84
5		0												-237.856	-2060.98	145.816	-199.968	-2035.09	155.712	-234.312	-2042.32	149.933	-220.096	-2057.48	148.7
6		0												-241.377	-2059.81	150.897	-203.038	-2033.78	159.39	-237.608	-2041.15	153.963	-223.519	-2056.69	154.03
7		0												-244.77	-2057.78	156.325	-206.096	-2032.13	162.86	-240.642	-2039.22	157.905	-226.946	-2055.03	159.15
8		0												-248.741	-2056.67	160.965	-209.357	-2031.47	166.284	-244.062	-2038.18	161.649	-230.977	-2053.66	163.49
9		0												-252.751	-2055	164.576	-212.331	-2031.23	168.014	-247.503	-2037.2	164.522	-234.654	-2052.79	166.38
10		0												-256.057	-2052.59	167.55	-215.083	-2029.39	167.49	-250.093	-2034.16	165.473	-237.641	-2050.51	168.3
11		0												-258.635	-2048.68	170.183	-217.174	-2027.15	165.829	-252,316	-2030.72	166.428	-240.411	-2047.38	169.81
12		0												-260.852	-2045.29	171.447	-219.255	-2026.06	162.139	-254.956	-2027.74	165.851	-242.63	-2044.23	169.97
13		0												-262.824	-2043.01	172.344	-221.601	-2024.38	159.53	-256.797	-2026.23	165.513	-244,409	-2042.53	169.34
14		0												-264.886	-2041.33	173.432	-223.967	-2024.43	157.919	-259.088	-2025.77	164.818	-246.543	-2041.67	169.60
15		0												-267.296	-2042.42	173.888	-226.637	-2025.87	157.547	-260.817	-2026.1	165.526	-248,975	-2042.39	169.52
16		0												-269.853	-2043.81	174.686	-229.061	-2027.73	157.637	-263.577	-2027.85	166.685	-251.723	-2044.69	169.71
17		0												-272.538	-2046.01	175.136	-231,646	-2030.44	157.662	-265.78	-2028.94	167.387	-254.805	-2046.59	170.11
18		0												-275.078	-2048.82	174.865	-234.348	-2034.21	157.516	-268.308	-2031.99	167.291	-257.461	-2050.1	169.26
19		0												-277.99	-2052.23	174.216	-237.241	-2037.41	156.877	-271.42	-2035.19	167.488	-260.359	-2053.33	168.18
20		0												-281.246	-2056.2	173.287	-240.082	-2040.87	156.145	-274.429	-2039.21	167.625	-264.031	-2057.74	166.88
21		0												-284.881	-2060.71	171.095	-243.61	-2045.37	155.1	-277.468	-2043.56	167.427	-267.688	-2062.45	164.94
22		0												-288.514	-2064.89	169.456	-247.049	-2049.94	153,889	-280.192	-2048.2	166.184	-271.656	-2065.56	162.69

Video

- Realtime access to VICON video files are not possible unless captured from screen of computer.
- Each camera has its own SSD, storage format .vvid
- Each video footage has to be exported to .avi using Nexus for visualisation.
- Nexus export gives distorted video. Nexus software internally undistorts the video for visualization.
- Additional tool is provided for undistortion of .vvid file to .avi,.mov format.

Important Notes

- Cameras can be relocated but not preferred due to holes in the net.
- Tracking near roof is poor due to lack of triangulation.
- Cameras can shut down due to over heating @ 35+ deg C.
- Tracker has better results for object (pattern) tracking than Nexus.
- 2D annotations are not provided for video, custom code is required for projection.
- .x3d files can be visualised in non-vicon software such as Mokka for session playback.

Available Code

- Real time acceess to tracking data (Python): Vicon example, Couzin Lab
- .dll availble for c++ development : Vicon example code
- Vicon_DataRead : Git Repo for computer vision tasks with example code for,
 - Reading Nexus, Tracker .csv output
 - Reading calibration file
 - Projection of 3D data on 2D images
 - Reasonable comments and Working code exmaples