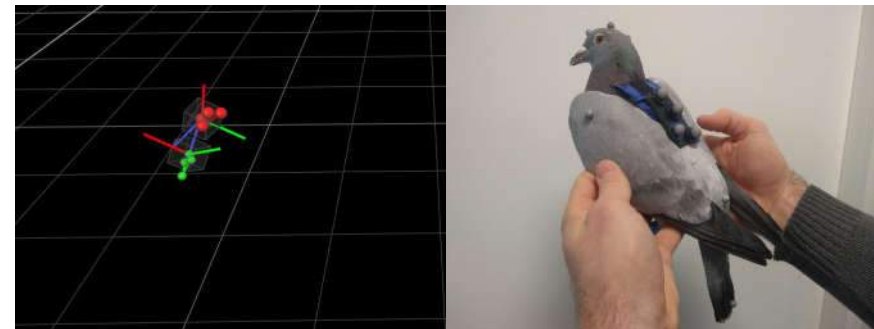
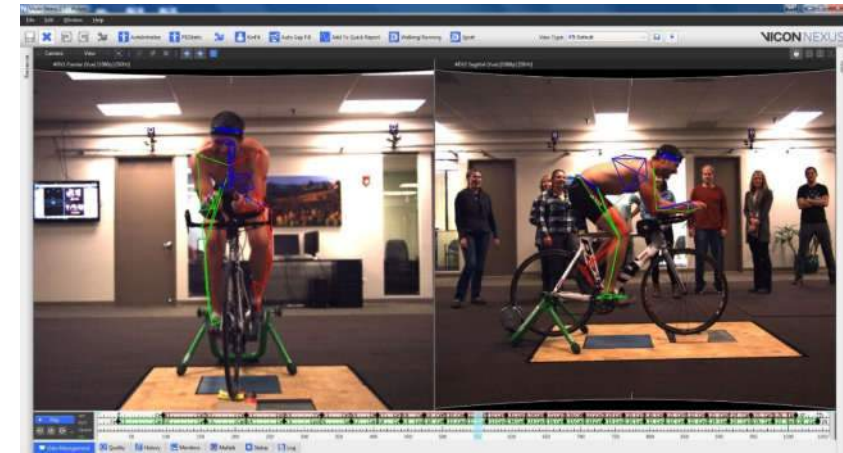


Introduction VICON

Hemal Naik

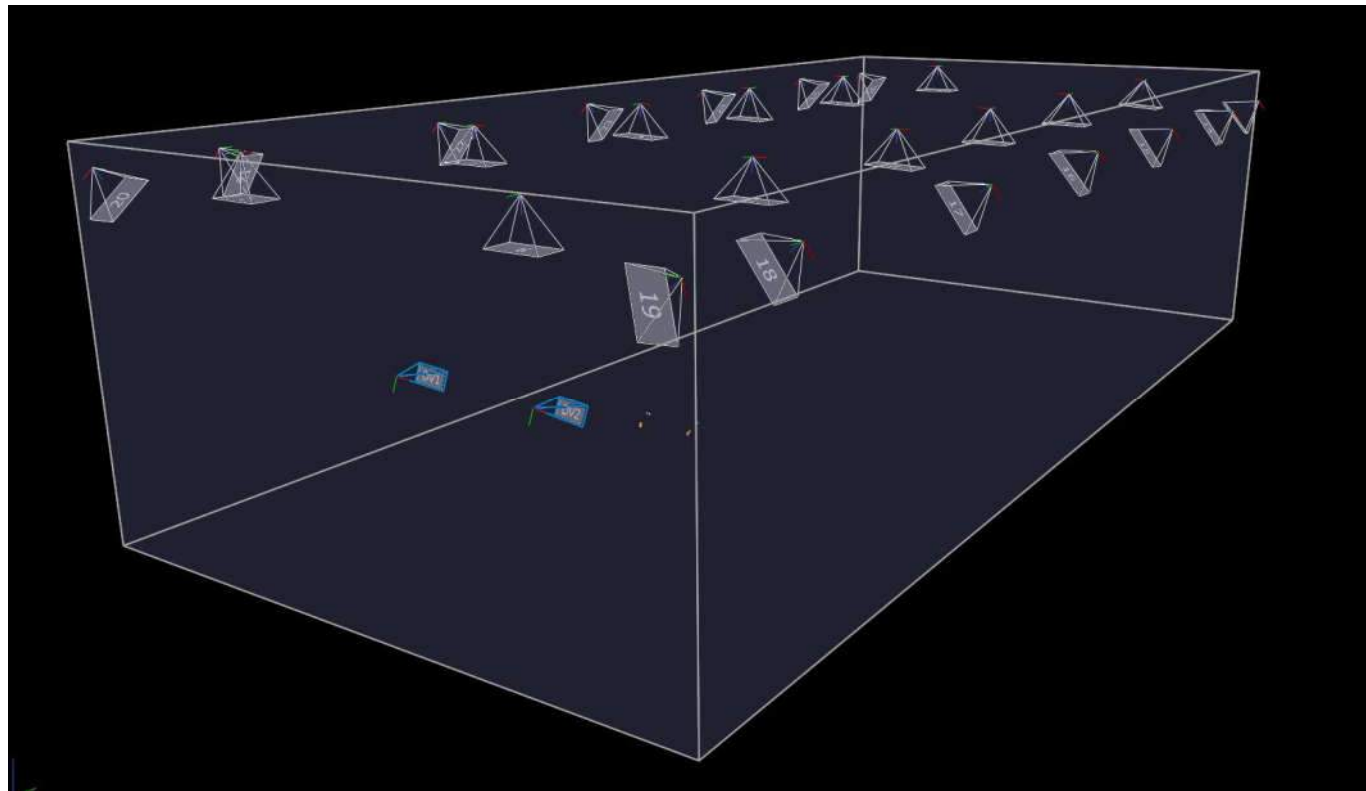
Features

- 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

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<Cameras SOURCE="Nexus 2.7.1.107809h" VERSION="2.0">

  <Camera ACTIVE_THRESHOLD="1" DEVICEID="2118670" DISPLAY_TYPE="Vue" ISDV="2" NAME="" PIXEL_ASPECT_RATIO="1" SENSOR="Vue 2" SENSOR_SIZE="1920 1080" SYSTEM="DV" TYPE="Vue_VIDEO" USERID="0">
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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/>
    <KeyFrames>
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        PRINCIPAL_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"/>
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    </KeyFrames>
  </Camera>

  <Camera ACTIVE_THRESHOLD="1" DEVICEID="2121077" DISPLAY_TYPE="Vero v2.2" ISDV="0" NAME="" PIXEL_ASPECT_RATIO="1" SENSOR="Vero 2.2" SENSOR_SIZE="2048 1088" SYSTEM="MX" TYPE="VeroV22" USERID="22">
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  </Camera>


```

Measurements : Object

- Object – Defined in either software as pattern of 4 Markers
- Each object has its own coordinate system.
- 4 Markers – p_1, p_2, p_3, p_4
- X – Axis : $\text{Vector}(p_1 p_2)$
- Y – Axis : $\text{Cross}(\text{Vector}(p_1 p_2), \text{Vector}(p_1 p_3))$
- Z – Axis : $\text{Cross}(\text{X- Axis}, \text{Y- Axis})$
- .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 triangulation can be changed, but not related to capture.
- Objects can be defined, modified and reprocessed offline.

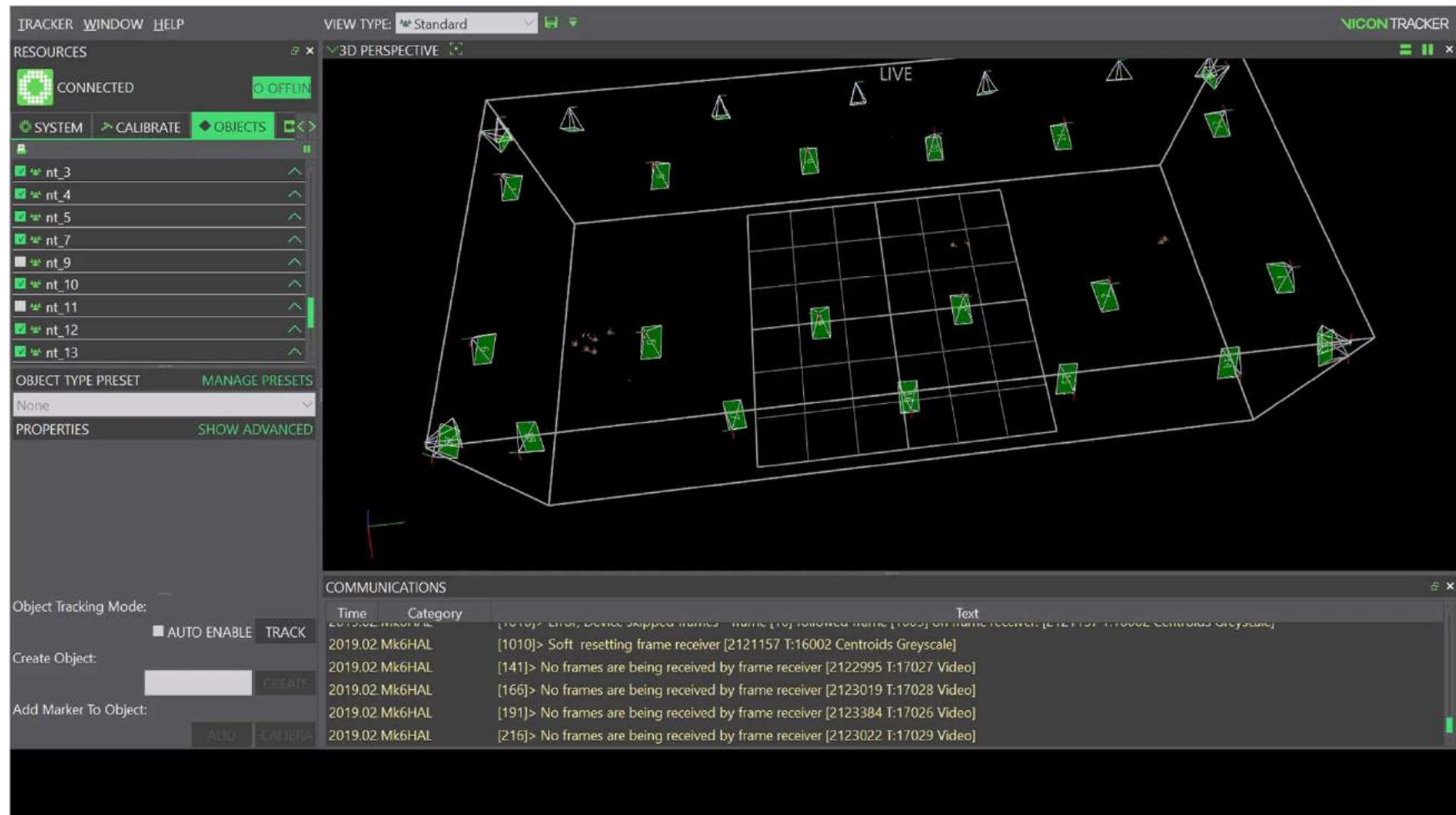
Real-Time communication - online

- 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 is 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																
Global Angle (Quaternion) backpack_20190131:backpack_20190131									Global Angle (Quaternion) pigeonHead_20190131:pigeonHead_20190131							
Frame	Sub Frame	RX	RY	RZ	RW	TX	TY	TZ	RX	RY	RZ	RW	TX	TY	TZ	
						mm	mm	mm					mm	mm	mm	
1	0	-0.26731	0.080238	0.884146	-0.37469	-205.87	-2041.55	140.482	0.03953	0.21901	0.873896	0.432179	-285.898	-2058.67	163.202	
2	0	-0.27272	0.07235	0.886669	-0.36635	-210.69	-2044.69	141.811	0.039542	0.218612	0.871437	0.437314	-289.096	-2061.59	163.79	
3	0	-0.27823	0.07823	0.88364	-0.3683	-215.553	-2046.97	144.235	0.036292	0.218398	0.866534	0.44733	-291.609	-2063.53	164.466	
4	0	-0.28474	0.069391	0.886979	-0.3569	-219.896	-2048.77	146.613	0.048144	0.19375	0.876575	0.437904	-293.455	-2063.89	164.035	
5	0	-0.28423	0.081549	0.886717	-0.35538	-223.061	-2049.33	150.246	0.045118	0.204429	0.872808	0.440885	-294.362	-2063.8	164.177	
6	0	-0.27345	0.103242	0.886766	-0.35807	-226.444	-2048.16	154.754	0.03825	0.201713	0.874593	0.439245	-294.685	-2063.38	164.833	
7	0	-0.2575	0.132549	0.887799	-0.35768	-229.635	-2046.16	159.292	0.041468	0.186811	0.880342	0.434028	-295.861	-2062.6	166.264	
8	0	-0.24508	0.149451	0.890687	-0.35253	-233.286	-2045.19	163.446	0.029967	0.188116	0.876266	0.442575	-300.931	-2061.47	170.578	
9	0	-0.2222	0.154268	0.898627	-0.3454	-236.825	-2044.15	166.337	0.056828	0.198378	0.860234	0.466276	-308.419	-2058.53	177.314	
10	0	-0.18272	0.174615	0.902946	-0.34758	-239.76	-2041.87	167.978	-0.00445	-0.08572	0.56879	-0.81799	-305.715	-2048.44	181.619	
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	

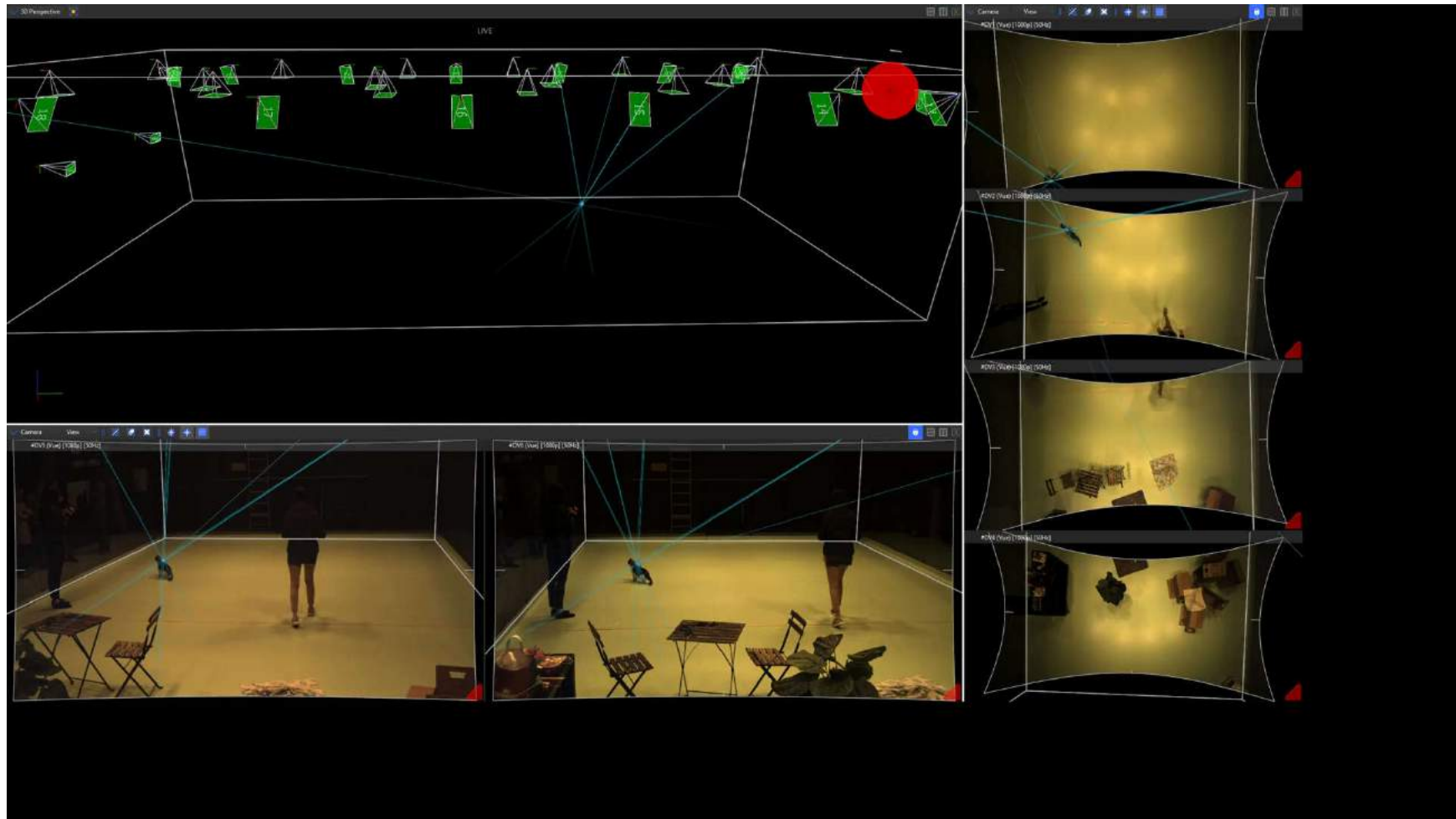
Output : Unlabelled

100		1										2										3										4										5										6										7										8										9										10										11										12																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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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.

Trajectories																												
100																												
		head:headPattern1			head:headPattern2			head:headPattern3			head:headPattern4			backpack:backpack1			backpack:backpack2			backpack:backpack3			backpack:backpack4					
Frame	Sub Frame	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	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	139.373			
2	0													-225.363	-2056.39	137.796	-187.854	-2030.02	146.733	-222.182	-2038.04	141.805	-207.492	-2052.63	140.158			
3	0													-230.242	-2058.99	140.048	-192.715	-2031.97	149.394	-226.997	-2040.37	143.969	-212.409	-2054.92	142.519			
4	0													-234.727	-2060.49	142.141	-196.714	-2034.23	152.299	-231.129	-2041.85	146.298	-216.701	-2056.4	144.844			
5	0													-237.856	-2060.98	145.816	-199.968	-2035.09	155.712	-234.312	-2042.32	149.933	-220.096	-2057.48	148.76			
6	0													-241.377	-2059.81	150.897	-203.038	-2033.78	159.39	-237.608	-2041.15	153.963	-223.519	-2056.69	154.039			
7	0													-244.77	-2057.78	156.325	-206.096	-2032.13	162.86	-240.642	-2039.22	157.905	-226.946	-2055.03	159.159			
8	0													-248.741	-2056.67	160.965	-209.357	-2031.47	166.284	-244.062	-2038.18	161.649	-230.977	-2053.66	163.499			
9	0													-252.751	-2055	164.576	-212.331	-2031.23	168.014	-247.503	-2037.2	164.522	-234.654	-2052.79	166.389			
10	0													-256.057	-2052.59	167.55	-215.083	-2029.39	167.49	-250.093	-2034.16	165.473	-237.641	-2050.51	168.35			
11	0													-258.635	-2048.68	170.183	-217.174	-2027.15	165.829	-252.316	-2030.72	166.428	-240.411	-2047.38	169.812			
12	0													-260.852	-2045.29	171.447	-219.255	-2026.06	162.139	-254.956	-2027.74	165.851	-242.63	-2044.23	169.979			
13	0													-262.824	-2043.01	172.344	-221.601	-2024.38	159.53	-256.797	-2026.23	165.513	-244.409	-2042.53	169.344			
14	0													-264.886	-2041.33	173.432	-223.967	-2024.43	157.919	-259.088	-2025.77	164.818	-246.543	-2041.67	169.608			
15	0													-267.296	-2042.42	173.888	-226.637	-2025.87	157.547	-260.817	-2026.1	165.526	-248.975	-2042.39	169.529			
16	0													-269.853	-2043.81	174.686	-229.061	-2027.73	157.637	-263.577	-2027.85	166.685	-251.723	-2044.69	169.719			
17	0													-272.538	-2046.01	175.136	-231.646	-2030.44	157.662	-265.78	-2028.94	167.387	-254.805	-2046.59	170.113			
18	0													-275.078	-2048.82	174.865	-234.348	-2034.21	157.516	-268.308	-2031.99	167.291	-257.461	-2050.1	169.268			
19	0													-277.99	-2052.23	174.216	-237.241	-2037.41	156.877	-271.42	-2035.19	167.488	-260.359	-2053.33	168.185			
20	0													-281.246	-2056.2	173.287	-240.082	-2040.87	156.145	-274.429	-2039.21	167.625	-264.031	-2057.74	166.888			
21	0													-284.881	-2060.71	171.095	-243.61	-2045.37	155.1	-277.468	-2043.56	167.427	-267.688	-2062.45	164.941			
22	0													-288.514	-2064.89	169.456	-247.049	-2049.94	153.889	-280.192	-2048.2	166.184	-271.656	-2066.56	162.695			

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 expored 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 access to tracking data (Python) : Vicon example, Couzin Lab
- .dll available 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 examples