Human Body Pose Estimation Missing Joints Reconstruction through Interpolations Comparison

In this work, we delve into the various n dimensional interpolation used to estimate the missing joints from the pose estimation of OpenPose.

1. Dataset Creation: to accomplish the goal of assign the best interpolation method for reconstructing missing frames of human body joints, a dataset has to be created.

   In order to obtain a ground truth dataset, all the sequences that have at least 5 sequential fully known values frames, have been retrieved from the original dataset, obtaining a dataset with 10,028 rows and 74 columns, for a total of 742,072 values.

   From this dataset, random sequences of missing points have been placed, dividing each columns in sequences based on sequential frame and video name.

NoseX	NoseY	NoseC	LEyeX	LEyeY	LEyeC	REyeX	REyeY	REyeC	LEarX	LEarY	LEarC	REarX	REarY	REarC	LShoulderX	LShoulderY	LShoulderC
0.401606	0.5202	0.831084	0.401527	0.510641	0.730255	0.398759	0.520298	0.697503	0.404232	0.491339	0.593905	0.398907	0.530033	0.409009	0.423458	0.486276	0.81084
0.401591	0.520243	0.849303	0.401529	0.510664	0.758677	0.396182	0.520339	0.719071	0.404252	0.491309	0.60373	0.39889	0.530109	0.392076	0.423454	0.486305	0.806153
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.423469	0.486342	0.801978
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.423468	0.486339	0.80523
0	0	0	0	0	0	0.398763	0.520419	0.66846	0.404274	0.491372	0.602178	0	0	0	0	0	0
0.401573	0.520413	0.828501	0.401545	0.51545	0.764389	0.398763	0.520447	0.648469	0.40432	0.495998	0.594207	0.401423	0.530097	0.292935	0.423516	0.486391	0.800324
0.398829	0.520434	0.814817	0.398816	0.515389	0.77608	0.39074	0.520568	0.627781	0.401661	0.49136	0.656558	0.398746	0.529962	0.195311	0.423477	0.486178	0.82624
0.398836	0.520334	0.826516	0.398814	0.510719	0.770468	0.393355	0.520476	0.633394	0.40168	0.491242	0.672432	0.398774	0.525473	0.20905	0.423513	0.481695	0.832449
0.398888	0.520368	0.839831	0.398854	0.510719	0.780024	0.393398	0.52051	0.62711	0	0	0	0.39877	0.525413	0.192991	0	0	0
0.401448	0.520275	0.830452	0.398882	0.510619	0.763428	0	0	0	0	0	0	0.398829	0.525395	0.236703	0.426074	0.481602	0.838588
0.401444	0.520163	0.817774	0.398859	0.510519	0.745219	0	0	0	0	0	0	0.398853	0.525364	0.292568	0.423515	0.481555	0.849206
0.398904	0.520192	0.820488	0.398843	0.510544	0.748448	0.393445	0.520335	0.624543	0.401641	0.491217	0.67187	0.398814	0.525403	0.27113	0.423503	0.481573	0.847431
0.401536	0.515476	0.804385	0.401516	0.50569	0.742377	0.396181	0.52008	0.694673	0.404196	0.491298	0.550921	0.398838	0.525258	0.441969	0.423471	0.481638	0.835873
0	0	0	0.401498	0.505694	0.741592	0.396169	0.520101	0.687774	0.401701	0.491307	0.55983	0.398841	0.525274	0.418002	0.423467	0.481631	0.838082
0.401515	0.520286	0.833196	0.401498	0.510667	0.780196	0.396168	0.520364	0.660748	0	0	0	0.398802	0.525357	0.263767	0	0	0
0	0	0	0.401503	0.515405	0.819898	0.396133	0.520547	0.665273	0	0	0	0.398775	0.525409	0.189452	0	0	0
0.401494	0.520517	0.897993	0.401501	0.515426	0.867931	0.396091	0.524968	0.713403	0.404291	0.491295	0.713471	0.396177	0.525453	0.160551	0.426085	0.481639	0.825437
0.401664	0.520432	0.838309	0.401623	0.51535	0.775447	0.398868	0.52051	0.523883	0.404421	0.491332	0.648427	0.401512	0.525299	0.170042	0.42889	0.48621	0.83261
0.401712	0.520461	0.832494	0	0	0	0	0	0	0.404432	0.49132	0.658833	0.401546	0.525253	0.189156	0.428892	0.48616	0.834981
0.404215	0.525056	0.868245	0.401715	0.515504	0.828685	0	0	0	0.407023	0.491308	0.692642	0	0	0	0	0	0
0	0	0	0	0	0	0.398915	0.525032	0.529516	0.404486	0.491258	0.698668	0	0	0	0.428948	0.481716	0.834024
0	0	0	0.404208	0.515374	0.813818	0.401497	0.524967	0.574043	0.407056	0.491252	0.68526	0	0	0	0.428958	0.48616	0.822059
0.404264	0.520539	0.833052	0.404221	0.515429	0.79056	0.401513	0.520583	0.53415	0.40704	0.491319	0.670467	0.401652	0.525271	0.159643	0.428973	0.486174	0.818843
0.600854	0.360113	0.837288	0.614338	0.364729	0.760266	0.603472	0.340848	0.760931	0.60624	0.374622	0.467758	0.597877	0.335918	0.559898	0.579085	0.428127	0.794178
0.600736	0.360054	0.867444	0.608996	0.364745	0.797349	0.600834	0.345523	0.769306	0	0	0	0	0	0	0.581759	0.432984	0.79035
0.600738	0.364925	0.894064	0.608996	0.365143	0.805143	0.600865	0.355193	0.789909	0.603583	0.3844	0.510346	0	0	0	0	0	0
0.600715	0.364934	0.884783	0.611641	0.365193	0.78202	0.600856	0.35519	0.769349	0	0	0	0	0	0	0.578968	0.437838	0.822133
0.600677	0.365057	0.849987	0.608924	0.369715	0.736491	0.600803	0.355323	0.748469	0	0	0	0	0	0	0	0	0
0	0	0	0.603585	0.370061	0.78368	0	0	0	0	0	0	0	0	0	0.57885	0.442548	0.81938
0	0	0	0.606228	0.369711	0.728597	0.600778	0.355227	0.656174	0.600868	0.398841	0.625283	0	0	0	0.57351	0.437742	0.764452
0	0	0	0.606193	0.369931	0.674828	0	0	0	0.600673	0.403626	0.574186	0	0	0	0.567991	0.432902	0.683871
0	0	0	0.603534	0.374795	0.487962	0	0	0	0	0	0	0.597933	0.360199	0.33768	0.568039	0.41844	0.491893
0	0	0	0.603449	0.370031	0.37056	0.6007	0.364988	0.386532	0.598111	0.398954	0.28167	0	0	0	0	0	0
0.598084	0.379568	0.249924	0.600832	0.374771	0.180003	0.600702	0.369955	0.23093	0.597976	0.379604	0.139244	0.597972	0.369794	0.21779	0.55983	0.394056	0.280756
0.407116	0.442465	0.718413	0.407047	0.428097	0.677203	0.404453	0.432924	0.30462	0.417896	0.408622	0.859012	0.404252	0.423293	0.118526	0.445325	0.398982	0.758768

Small portion of how the missin values dataset looks like.

2. Analysis on this dataset: Some analyses that can be made on it, regards the total number of zeros generated.
3. Interpolation comparison:
   - Linear
   - Inverse Distance Weight
   - Nearest Neighbor
   - CubicSpline
   - Akima
   - Pchip
   - Whittaker Shannon

   All these interpolations are then applied on the zero filled dataset.
4. Evaluation Metrics:

   The metrics involved to compare the interpolations are the following:
   - RMSE
   - Pearson Coefficient
   - Cosine Similarity
   - Euclidean Distance

   The metrics are applied only on the reconstructed sequences, the known values are not taken into account.

   The results are then listed:

   Akima :
   Euclidean Distance: 15.286
   Cosine Similarity: 0.99917
   Pearson Correlation Coefficient: 0.9929780441232688
   Root Mean Squared Error: 0.025471

   IDW :
   Euclidean Distance: 13.99
   Cosine Similarity: 0.9993

Pearson Correlation Coefficient: 0.9940978100464436
Root Mean Squared Error: 0.023312

Linear :
Euclidean Distance: 12.613
Cosine Similarity: 0.99943
Pearson Correlation Coefficient: 0.9952066445134503
Root Mean Squared Error: 0.021018

Spline :
Euclidean Distance: 16.715
Cosine Similarity: 0.999
Pearson Correlation Coefficient: 0.9916231349463192
Root Mean Squared Error: 0.027852

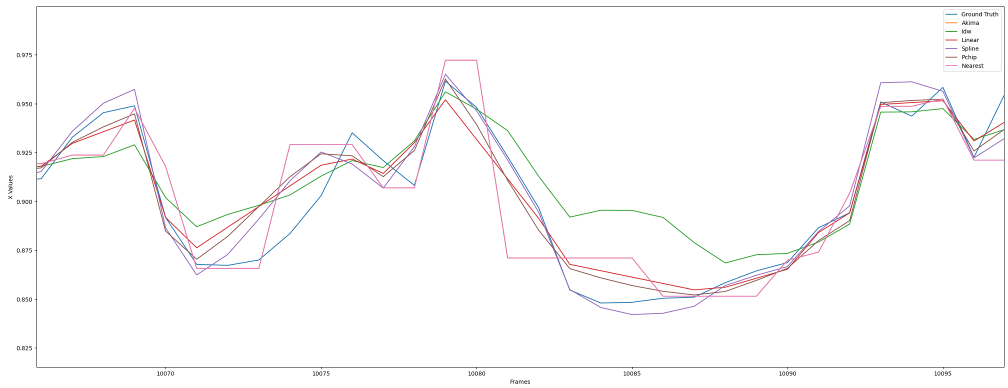
Pchip :
Euclidean Distance: 12.967
Cosine Similarity: 0.9994
Pearson Correlation Coefficient: 0.9949367262151254
Root Mean Squared Error: 0.021606

Nearest :
Euclidean Distance: 15.286
Cosine Similarity: 0.99917
Pearson Correlation Coefficient: 0.9929780441232688
Root Mean Squared Error: 0.025471

From the results, the Linear Interpolation seems to interpolate values with a higher accuracy than others.

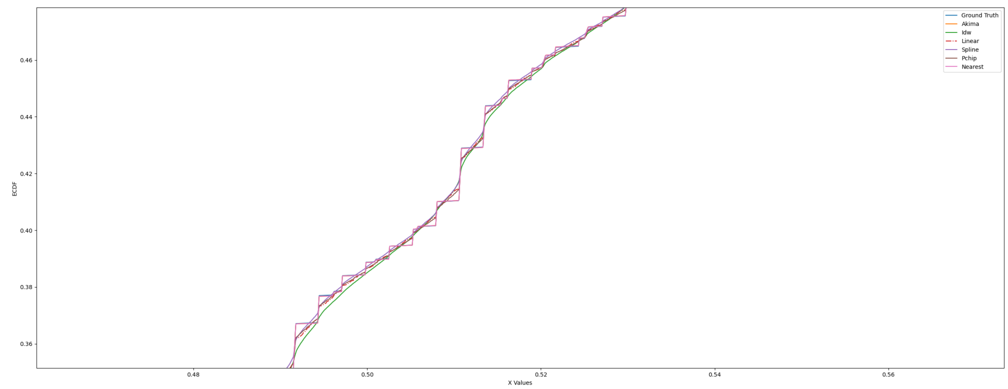
5. Visual Inspections

The results are then illustrated:



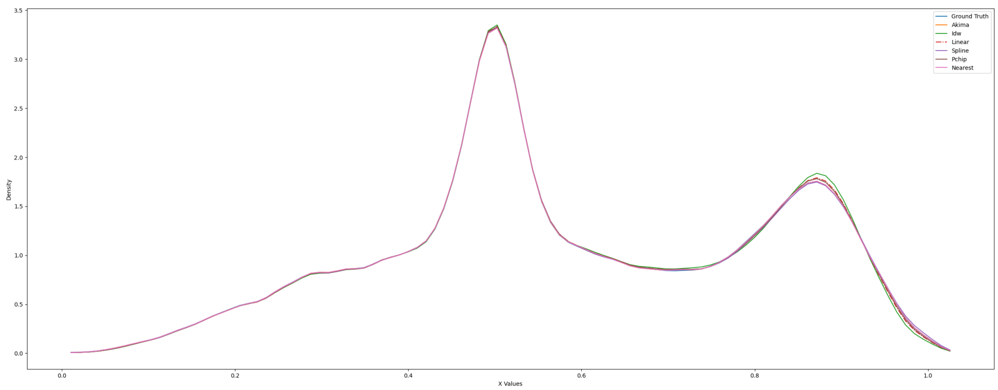
Small portion of the interpolation comparison.

Considering the high quantity of unique continous values, a ECDF representation has been employed:



Small portion of the whole ECDF function.

Finally, a density estimation plot has been created, to observe the sequences behaviour with less noise.



And a closer looks is then illustrated: