MSR-GCN: Multi-Scale Residual Graph Convolution Networks for Human Motion Prediction

Lingwei Dang [1], Yongwei Nie [1*], Chengjiang Long [2], Qing Zhang [3], Guiqing Li [1]

[1] South China University of Technology, [2] JD Finance America Corporation, [3] Sun Yat-sen University

csdanglw@mail.scut.edu.cn, nieyongwei@scut.edu.cn, cjfykx@gmail.com, zhangqing.whu.cs@gmail.com, ligq@scut.edu.cn

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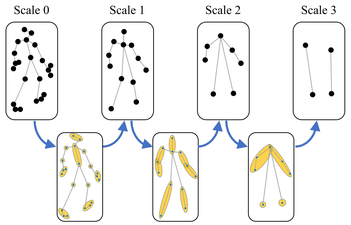
Motivation

- Human motion prediction is a challenging task due to the stochasticity and aperiodicity of future poses.
- Graph convolutional network has been proven to be very effective to learn dynamic relations among pose joints, which is helpful for pose prediction.
- One can abstract a human pose recursively to obtain a set of poses at multiple scales. With the increase of the abstraction level, the motion of the pose becomes more stable, which benefits pose prediction too.



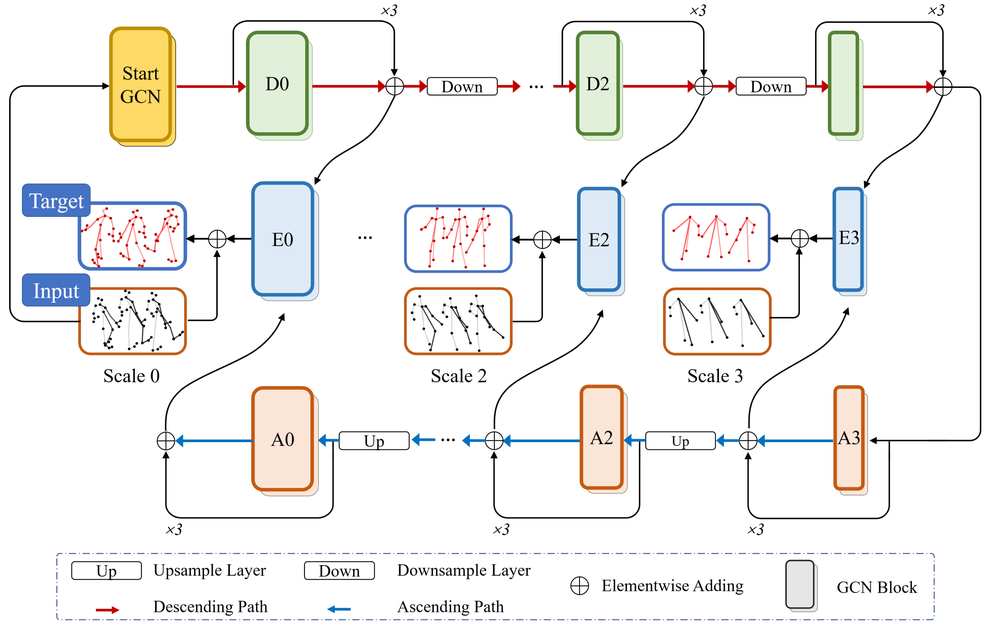
Contributions

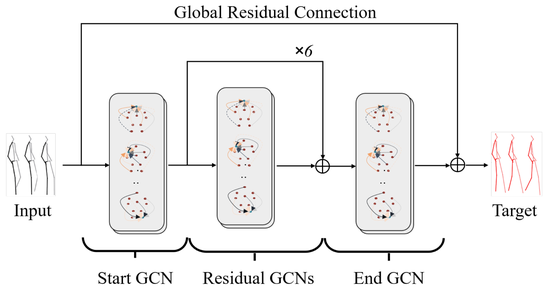
- We propose a novel multi-scale residual graph convolution network for human pose prediction in an end-to-end manner, which consists of multiple GCNs organized in a multi-scale architecture.
- The well-designed descending and ascending GCN blocks can extract features in both fine-to-coarse and coarse-to-fine manners.
- The intermediate supervision imposed at each scale enforces to learn more representative features, benefiting high-quality future prediction.

Datasets & Metric

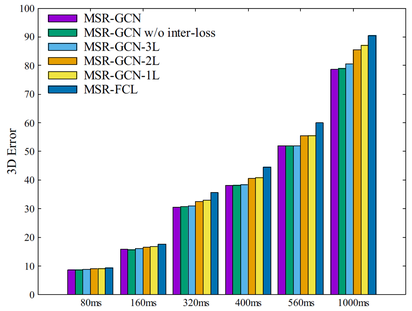
- Datasets: Human3.6M, CMU Mocap Dataset
- Metric: 3D Mean Per Joint Position Error (MPJPE)

Proposed Approach





Basic residual GCN model



Errors of different ablation variants on CMU Mocap

Quantitative Results

Short-term errors on H3.6M

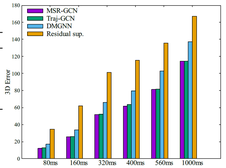
scenarios	walking				eating				smoking				discussion			
millisecond (ms)	80	160	320	400	80	160	320	400	80	160	320	400	80	160	320	400
Residual sup. [34]	29.36	50.82	76.03	81.51	16.84	30.60	56.92	68.65	22.96	42.64	70.14	82.68	32.94	61.18	90.92	96.19
DMGNN [27]	17.32	30.67	54.56	65.20	10.96	21.39	36.18	43.88	8.97	17.62	32.05	40.30	17.33	34.78	61.03	69.80
Traj-GCN [33]	12.29	23.03	39.77	46.12	**8.36**	**16.90**	33.19	40.70	**7.94**	**16.24**	31.90	38.90	12.50	27.40	58.51	71.68
MSR-GCN	**12.16**	**22.65**	**38.64**	**45.24**	8.39	17.05	**33.03**	**40.43**	8.02	16.27	**31.32**	**38.15**	**11.98**	**26.76**	**57.08**	**69.74**
scenarios	directions				greeting				phoning				posing			
millisecond (ms)	80	160	320	400	80	160	320	400	80	160	320	400	80	160	320	400
Residual sup. [34]	35.36	57.27	76.30	87.67	34.46	63.36	124.60	142.50	37.96	69.32	115.00	126.73	36.10	69.12	130.46	157.08
DMGNN [27]	13.14	24.62	64.68	81.86	23.30	50.32	107.30	132.10	12.47	25.77	48.08	58.29	15.27	29.27	71.54	96.65
Traj-GCN [33]	8.97	19.87	43.35	**53.74**	18.65	38.68	77.74	93.39	10.24	21.02	42.54	52.30	13.66	29.89	**66.62**	**84.05**
MSR-GCN	**8.61**	**19.65**	**43.28**	53.82	**16.48**	**36.95**	**77.32**	**93.38**	**10.10**	**20.74**	**41.51**	**51.26**	**12.79**	**29.38**	66.95	85.01
scenarios	purchases				sitting				sittingdown				takingphoto			
millisecond (ms)	80	160	320	400	80	160	320	400	80	160	320	400	80	160	320	400
Residual sup. [34]	36.33	60.30	86.53	95.92	42.55	81.40	134.70	151.78	47.28	85.95	145.75	168.86	26.10	47.61	81.40	94.73
DMGNN [27]	21.35	38.71	75.67	92.74	11.92	25.11	44.59	50.20	14.95	32.88	77.06	93.00	13.61	28.95	45.99	58.76
Traj-GCN [33]	15.60	32.78	**65.72**	**79.25**	10.62	**21.90**	46.33	57.91	16.14	**31.12**	**61.47**	**75.46**	**9.88**	**20.89**	44.95	56.58
MSR-GCN	**14.75**	**32.39**	66.13	79.64	**10.53**	21.99	**46.26**	**57.80**	**16.10**	31.63	62.45	76.84	9.89	21.01	**44.56**	**56.30**
scenarios	waiting				walkingdog				walkingtogether				Average			
millisecond (ms)	80	160	320	400	80	160	320	400	80	160	320	400	80	160	320	400
Residual sup. [34]	30.62	57.82	106.22	121.45	64.18	102.10	141.07	164.35	26.79	50.07	80.16	92.23	34.66	61.97	101.08	115.49
DMGNN [27]	12.20	24.17	59.62	77.54	47.09	93.33	160.13	171.20	14.34	26.67	50.08	63.22	16.95	33.62	65.90	79.65
Traj-GCN [33]	11.43	23.99	50.06	61.48	23.39	46.17	83.47	95.96	10.47	21.04	38.47	45.19	12.68	26.06	52.27	63.51
MSR-GCN	**10.68**	**23.06**	**48.25**	**59.23**	**20.65**	**42.88**	**80.35**	**93.31**	**10.56**	**20.92**	**37.40**	**43.85**	**12.11**	**25.56**	**51.64**	**62.93**

Long-term errors on H3.6M

scenarios	walking		Eating		Smoking		Discussion		Directions		average	
millisecond (ms)	560	1000	560	1000	560	1000	560	1000	560	1000	560	1000
Residual sup.[34]	81.73	100.68	79.87	100.20	94.83	137.44	121.30	161.70	110.05	152.48	97.56	130.50
DMGNN [27]	73.36	95.82	58.11	86.66	50.85	72.15	**81.90**	138.32	110.06	115.75	74.85	101.74
Traj-GCN [33]	54.05	**59.75**	53.39	77.75	50.74	72.62	91.61	121.53	**71.01**	101.79	64.16	86.69
MSR-GCN	**52.72**	63.04	**52.54**	**77.11**	**49.45**	**71.64**	88.59	**117.59**	71.18	**100.59**	**62.89**	**86.00**

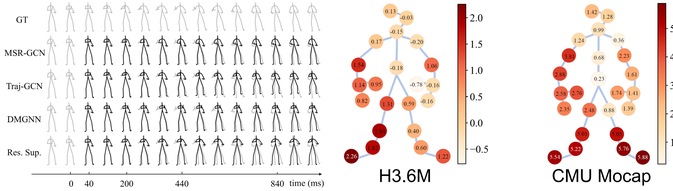
Long-term errors on CMU Mocap

scenarios	basket	bas_sig	dir_tra	jumping
Residual sup.[34]	**72.83**	60.57	153.12	162.84
DMGNN [27]	138.62	52.04	111.23	224.63
Traj-GCN [33]	97.99	54.00	114.16	127.41
MSR-GCN	86.96	**47.91**	**111.04**	**124.79**
scenarios	running	soccer	walking	washwin
Residual sup.[34]	158.19	107.37	194.33	202.73
DMGNN [27]	**46.40**	111.90	67.01	82.84
Traj-GCN [33]	51.73	108.26	**34.41**	**66.95**
MSR-GCN	48.03	**99.32**	39.70	71.30



Average error on H3.6M

Qualitative Results



Visualization on H3.6M

Performance gain over Traj-GCN

Key References

[Traj-GCN] Mao W, Liu M, Salzmann M, *et al.* : Learning trajectory dependencies for human motion prediction. ICCV, 2019.
[DMGNN] Li M, Chen S, Zhao Y, *et al.* : Dynamic multiscale graph neural networks for 3d skeleton based human motion prediction. CVPR, 2020.
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Acknowledgement

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