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あらまし 3 … 2 … Deep Convolutional Neural Network DCNN … DCNN …

キーワード 3 …

Preliminary study on deep manifold embedding for 3D object pose estimation

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Abstract Recently, 3D object pose estimation is being focused. The parametric eigenspace method is known as one of the fundamental methods. It represents the appearance change of an object caused by pose change with a manifold embedded in a low-dimentional subspace. It obtains features by PCA, which maximizes the appearance variation. However, there is not always a correlation between pose change and appearance change. So, there is a problem that the method cannot handle a pose change with a slight appearance change. In this report, we introduce deep manifold embedding which maximizes the pose variation. We construct a manifold from features extracted from Deep Convolutional Neural Networks (DCNNs) trained with pose information. Pose estimation with the proposed method achieved the best accuracy in experiments using a public dataset.

Key words 3D object, pose estimation, manifold, deep learning

1. まえがき

[illegible] Amazon Picking Challenge [1] [illegible] [2] [illegible]

[illegible] [3] [illegible] [4] [illegible]

[illegible] Murase [illegible] [4] [illegible]

[illegible] Deep

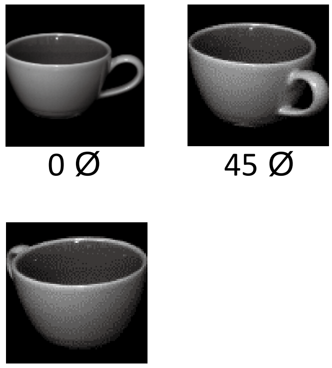


図 1 [illegible]

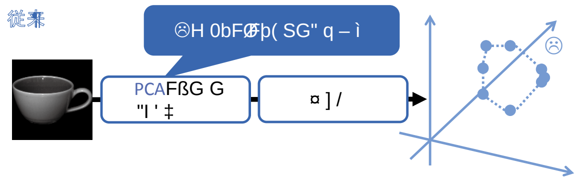


図 2 PCA [illegible]

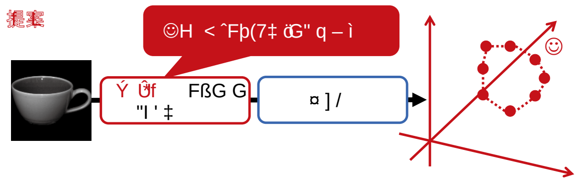
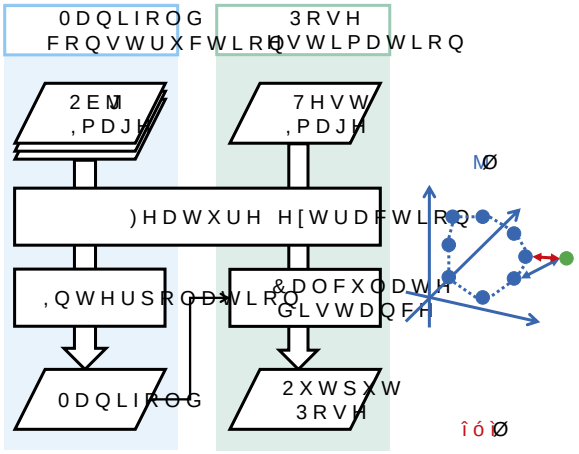


図 3 [illegible]

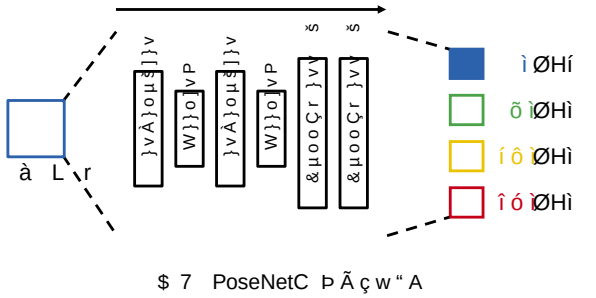
Convolutional Neural Network (DCNN) [5] [illegible] DCNN [illegible] [6] [illegible] 1 [illegible] DCNN [illegible] 2 [illegible] 3 [illegible] 4 [illegible] 5 [illegible]

2. 多様体に基づく姿勢推定

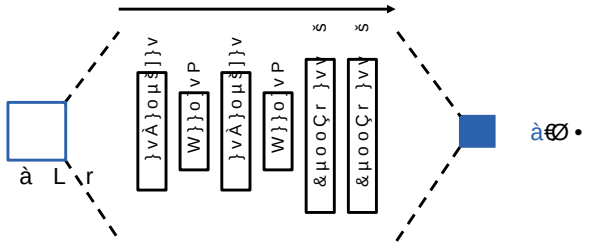
[illegible] 4 [illegible]



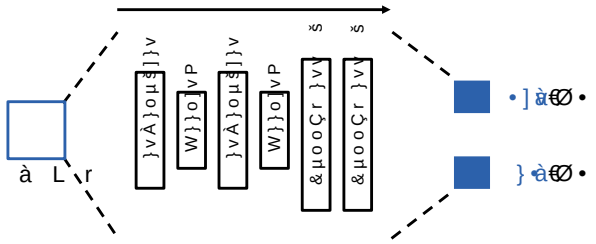
$ 4 7.Ï™t,nXŸN* rg q



$ 7 PoseNetC Þ Ã ç w“ A



$ 8 PoseNetR Þ Ã ç w“ A



$ 9 TriNetR Þ Ã ç w“ A

$ 5 ŸN›-£ô ø q`h DCNN w¶6 q

$ 6 ¶6A^ DCNN T’w ›Ã¨Z q

U ÉpK”}f\p| 7.Ï™tŸN›-£ô ø q`h-£K“¶6 O›;M”\qUßQ’•”}
fw¤p|f‘x Ú¶6t‘”›Ã¨Zt£è`h} Ú¶6qx;•¶6 Ow 1mpK“|›Ã¨ZT’Ý ‡p›° `o¶6pV” OpK”}\•t‘“¶6^•”›Ã” x pƒ-^•h›Ã”qz±`oôM¯qó—›Ëj|wÝ +w¶6tSMo‹ ®pK”\qUŒ’•oM” [7]}‡h|ú.wíòwÝÝw‘Os| t‘”›Ãƒ-UÉ` MðJtSMo‹| Ú¶6t‘“¨Z^•h›Ã”xôMQó›Ôb [8]}\w\qT’|ŸN›-£ô ø q`o¶6`hÚ¶6ÞÃç›;M”\qp|ŸNwümQwôM›Ã¨ZUpV”qßQ’•”}f`o|fw›Ã”›;MoÏ™`h7.s’y| Rüüst‘” 7.px0 pVsM_Qw!=U–^MŸNw§M›à b”\qUpV”}
Ú¶6›;Mh 7.Ï™›æsOhŠtx|‡c Ú¶6ÞÃçw 1mpK” DCNN w¶6›æO}¶6±ïÓç›t x|* 0Åú.›Ú™ws8àtHlo|° w¯S]qt s8^dhhþ›;M”}\\p|$ 5tÔb‘Ot|-£ô ø q`o¤ú.wŸN›)Q”}\•t‘“|ŸNwümQt £è`h¶6Uæ˜•”}f`o|¶6`h DCNN ›;Mo›Ã¨Z›æO}$ 6tfwrg q›Ôb}¶6`h DCNN t* 0Åú.w¶6±ïÓç›6|Ö—`|¤ ÚwZ—››Ã”q`o¨Zb”}\w‘Ot¨Z`h›Ã”t0`|Íåݍæ¿«{ í Oq‰7t4 rg›æsM| 7.›Ï™b”}

3. ŸN›-£ô ø q`h DCNN w¶6

ŸNwümQUôM›Ã›¨Zb”hŠt|ŸN›-£ô ø q`o DCNN ›¶6b”}fwM|-£ô øw)QMwŸs”Ž<w 3mwÞÃç› Šb”}

- € PoseNetC•ú.ŸN›-£ô ø q`hü¨ÞÃç}
- € PoseNetR•ú.ŸN›-£ô ø q`hs<ÞÃç}
- € TriNetR •ŸNw3¯ :‹›-£ô ø q`hs<ÞÃç}

3.1 PoseNetC

PoseNetC qxú.ŸN›-£ô ø q`hü¨ÞÃçpK”}\wÞÃçpx|ŸN›m„=`|ŸN* ðJ›«åµü¨ðJq`o Ü=b”}

$ 7tÞÃçw“A›Ôb}¶owú.pfw ¨t‘’c|ŸN›-£ô ø q`o¶6›æsO}m‡“|ŸN ›m„=`|0 b”«åµwˆ› 1|f•ŽŽ› 0q`h¶6›æsO}fwhŠ| Output layer wUnit :x¶6t;MhŸNw¨¡iZ Ob”}¡) :tx¦)¤ïÄéÐ”›;M”}\w‘Ot¶6›æsO\qp|›Ãí Íp‰°«åµtb”ŸNUf•g•Ÿs” 1:tB¤b”‘Os¶6Uæs

[illegible] 3 [illegible]

	[illegible]
Pixel	1.16 [illegible]
PCA	1.39 [illegible]
ObjNetC	1.70 [illegible]
PoseNetC	1.09 [illegible]
PoseNetR	1.59 [illegible]
TriNetR	1.72 [illegible]
OverFeat [13]	1.89 [illegible]

TriNetR [illegible] PoseNetR [illegible] PoseNetC [illegible]

$$\sin\theta^2 + \cos\theta^2 = 1 \quad (1)$$

[illegible] PoseNetC [illegible] 5 [illegible]

4.2 DCNN を用いた多様体構築による姿勢推定

[illegible] PoseNetC, PoseNetR, TriNetR [illegible] COIL-20 [illegible] ObjNetC [illegible] ImageNet 2012 training set [12] [illegible] OverFeat [illegible] [13] [illegible]

[illegible] Convolution layer [illegible] Fully-connected layer [illegible] COIL-20 [illegible] Fully-connect 3 [illegible] OverFeat [illegible] Fully-connect 8 [illegible] 512 [illegible] 4,096 [illegible] 80% [illegible] 10 [illegible] 16,384 [illegible] 2 [illegible] DCNN [illegible]

[illegible] 3 [illegible] PoseNetC [illegible] ObjNetC [illegible] OverFeat [illegible]

[illegible] 4 DCNN [illegible] Unit [illegible]

	Units: 256	Units: 512	Units: 1024
PoseNetC	12.36 [illegible]	7.92 [illegible]	7.33 [illegible]
PoseNetR	32.42 [illegible]	28.32 [illegible]	27.00 [illegible]
TriNetR	12.76 [illegible]	9.29 [illegible]	9.75 [illegible]

[illegible] 5 [illegible] Unit [illegible]

	Units: 256	Units: 512	Units: 1024
ObjNetC	1.76 [illegible]	1.70 [illegible]	1.91 [illegible]
PoseNetC	1.17 [illegible]	1.09 [illegible]	1.16 [illegible]
PoseNetR	1.59 [illegible]	1.59 [illegible]	1.75 [illegible]
TriNetR	1.62 [illegible]	1.73 [illegible]	2.11 [illegible]

[illegible] ObjNetC [illegible] OverFeat [illegible] PoseNetR [illegible] TriNetR [illegible] PoseNetC [illegible] PoseNetC [illegible] 2 [illegible] DCNN [illegible]

[illegible]

4.3 DCNN のネットワークアーキテクチャの違いが姿勢推定精度に与える影響

[illegible] DCNN [illegible] Fully-connected layer [illegible] Unit [illegible] Fully-connected layer [illegible] Unit [illegible] 256, 512, 1024 [illegible] 3 [illegible]

[illegible] 4, 5 [illegible] DCNN [illegible] Unit [illegible] 512 [illegible] DCNN [illegible] Unit [illegible] Unit [illegible]

5. むすび

[illegible]

ν Κ ρ Κ ᶅ ` Μ д ь ˒ Њ ς λ Κ ν ب ₮ Ɣ Ŋ ǫ ɰ Ï ο Ғ " مخي ╚ عجٍ
ȯ ’ ᛋ عج ς ؤ ΰ ɰ ǃ à Ƕ υ ب ₮ ثي Σ ả Ω ﾅ Ҷ ɰ ‘
謝辞 ᾅ ẓ υ ӿ لجي φ " ψ ᶅ ᾅ ẓ سد ˥ Ự ς Ѯ ɰ ‘

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