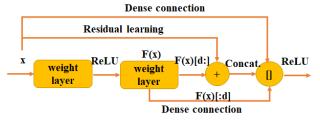
## **Update and Supplementary Material for Deep 3D Dual Path Nets for Automated Pulmonary Nodule Detection and Classification**

Anonymous WACV submission

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### 1. Fix the error in the manuscript

In the manuscript, Fig. 2 is a little hard to understand. The fixed figure is as follows.



Equation 1 is fixed as

 $\mathbf{y} = \mathbf{G}([\mathbf{H}(\mathbf{x})[: d], \mathbf{F}(\mathbf{x})[: d], \mathbf{F}(\mathbf{x})[d:] + \mathbf{H}(\mathbf{x})[d:]]),$  where  $\mathbf{H}(\mathbf{x})$  is the short cut activation employing  $1 \times 1 \times 1$  convolution. The 3D DPN has more feature maps and uses less filters for  $3 \times 3 \times 3$  convolution. More detailed network structure comparison is in Section 2 and Section 3.

# 2. Detailed network structure for 3D Faster R-CNN with Deep 3D Dual Path Net in Nodule Detection

The encoder network is adapted from DPN92 directly by changing  $7\times7$  filters into  $3\times3$  [1]. The numbers of blocks are changed from 3, 4, 20, 3 to 2, 2, 2, 2. The decoder network is to make the network symmetric. The stride 2 of 3D convolution is added in the first  $3\times3\times3$  convolution in each block.

| Stage     | Output       | Weights                                      |
|-----------|--------------|--|
| Pre-dual  | 96×96×96, 24 | 3×3×3, 24                                    |
| path      |              |  |
| Dual path | 48×48×48, 48 | $[1\times1\times1,24]$                       |
| block 1   |              | $3\times3\times3$ , 24, (stride 2) $\times2$ |
|           |              | (1×1×1, 32                                   |
| Dual path | 24×24×24, 72 | $\lceil 1 \times 1 \times 1, 48 \rceil$      |
| block 2   |              | $3\times3\times3$ , 48, (stride 2) $\times2$ |
|           |              | $\lfloor 1 \times 1 \times 1, 56 \rfloor$    |
| Dual path | 12×12×12, 96 | $[1\times1\times1,72]$                       |
| block 3   |              | $3\times3\times3$ , 72, (stride 2) $\times2$ |
|           |              | $\lfloor 1 \times 1 \times 1, 80 \rfloor$    |

| Dual path | 6×6×6, 120    | [1×1×1, 96]                                  |
|-----------|---------------|--|
| block 4   |               | $3\times3\times3$ , 96, (stride 2) $\times2$ |
|           |               | (1×1×1, 104                                  |
| Deconv. 1 | 12×12×12, 216 | 2×2×2, 216                                   |
| Dual path | 12×12×12, 152 | (1×1×1, 128                                  |
| block 5   |               | $\{3\times3\times3, 128\}$                   |
|           |               | [1×1×1, 136]                                 |
| Deconv. 2 | 24×24×24, 224 | 2×2×2, 152                                   |
| Dual path | 24×24×24, 248 | /1×1×1, 224                                  |
| block 6   |               | $\{3\times3\times3,224\}$ $\times2$          |
|           |               | $\lfloor 1 \times 1 \times 1, 232 \rfloor$   |
| Output    | 24×24×24, 3×5 | Dropout, p=0.5                               |
|           |               | $1\times1\times1$ , 64                       |
|           |               | 1×1×1, 15                                    |

### 3. Detailed network structure for 3D Faster R-CNN with Deep 3D Residual Network in Nodule Detection

The encoder network is adapted from Res18 directly by changing  $7\times7$  filters into  $3\times3$  [2]. We find the latest reference for 3D Res18 network in [3], and will add it into the reference.

| Stage         Output         Weights           Pre-Residual         96×96×96, 24         3×3×3, 24           Residual         48×48×48, 32         3×3×3, 32           Block 1         24×24×24, 64         3×3×3, 64           Block 2         12×12×12, 64         3×3×3, 64, (stride 2) ×2           Residual         12×12×12, 64         3×3×3, 64, (stride 2) ×3           Block 3         6×6×6, 64         3×3×3, 64, (stride 2) ×3           Residual         6×6×6, 64         3×3×3, 64           Block 4         3×3×3, 64, (stride 2) ×3           Deconv. 1         12×12×12, 128         2×2×2, 64           Residual         12×12×12, 64         3×3×3, 64           Block 5         3×3×3, 64           Deconv. 2         24×24×24, 128         2×2×2, 64           Residual         24×24×24, 64         3×3×3, 64           Block 6         3×3×3, 64         3×3×3, 64           Output         24×24×24, 3×5         Dropout, p=0.5           1×1×1, 64         1×1×1, 64  | the reference. |               |   |
|--|----------------|---------------|---|
| Residual         3×3×3, 24           Residual block 1         48×48×48, 32         [3×3×3, 32]           Residual block 2         24×24×24, 64         [3×3×3, 64]         [3×3×3, 64]           Residual block 2         12×12×12, 64         [3×3×3, 64]         [3×3×3, 64]           Residual block 3         6×6×6, 64         [3×3×3, 64]         [3×3×3, 64]           Residual block 4         [3×3×3, 64]         [3×3×3, 64]         [3×3×3, 64]           Deconv. 1         12×12×12, 128         2×2×2, 64         [3×3×3, 64]         [3×3×3, 64]           Block 5         [3×3×3, 64]   | Stage          | Output        | Weights   |
| Residual block 1         48×48×48, 32         \$\begin{array}{c} 3×3×3, 32 \\ 3×3×3, 32, (stride 2) \times 2 \end{array}\$           Residual block 2         24×24×24, 64         \$\begin{array}{c} 3×3×3, 64 \\ 3×3×3, 64, (stride 2) \times 2 \end{array}\$           Residual block 3         6×6×6, 64         \$\begin{array}{c} 3×3×3, 64 \\ 3×3×3, 64, (stride 2) \times 3 \end{array}\$           Residual block 4         \$\begin{array}{c} 3×3×3, 64 \\ 3×3×3, 64, (stride 2) \times 3 \end{array}\$           Deconv. 1         \$12×12×12, 128         \$2×2×2, 64           Residual block 5         \$\begin{array}{c} 3×3×3, 64 \\ 3×   | Pre-           | 96×96×96, 24  | 3×3×3, 24   |
| block 1         3x3x3, 32, (stride 2) x2           Residual block 2         24x24x24, 64         \$\frac{3}{3}x3x3, 64, (stride 2) x2}\$           Residual block 3         12x12x12, 64         \$\frac{3}{3}x3x3, 64, (stride 2) x3}\$           Residual block 4         6x6x6, 64         \$\frac{3}{3}x3x3, 64, (stride 2) x3}\$           Deconv. 1         12x12x12, 128         2x2x2, 64           Residual block 5         \$\frac{3}{3}x3x3, 64 x3}\$           Deconv. 2         24x24x24, 128         2x2x2, 64           Residual block 6         \$\frac{3}{3}x3x3, 64 x3}\$           Output         24x24x24, 3x5         Dropout, p=0.5  | Residual       |               | 3×3×3, 24   |
| Residual block 2         24×24×24, 64         \$\frac{3\times 3\times 3, 64}{3\times 3\times 3, 64}\$, (stride 2) ×2           Residual block 3         \$12\times 12\times 12, 64\$         \$\frac{3\times 3\times 3, 64}{3\times 3\times 3, 64}\$, (stride 2) \times 3           Residual block 4         \$6\times 6\times 6, 64\$         \$\frac{3\times 3\times 3, 64}{3\times 3\times 3, 64}\$, (stride 2) \times 3           Deconv. 1         \$12\times 12\times 12, 128\$         \$2\times 2\times 2, 64\$           Residual block 5         \$\frac{3\times 3\times 3, 64}{3\times 3\times 3, 64}\$, (stride 2) \times 3           Deconv. 2         \$24\times 24\times 24, 128\$         \$2\times 2\times 2, 64\$           Residual block 6         \$\frac{3\times 3\times 3, 64}{3\times 3\times 3, 64}\$, (stride 2) \times 3           Output         \$24\times 24\times 24, 3\times 5         Dropout, p=0.5  | Residual       | 48×48×48, 32  | $\int 3\times 3\times 3$ , 32                               |
| block 2  Residual block 3  Residual block 4  Deconv. 1  Residual block 5  Deconv. 2  24×24×24, 128  Residual block 6  Output 24×24×24, 3×5  Dropout, p=0.5   | block 1        |               | $3\times3\times3$ , 32, (stride 2) $\times2$                |
| Residual block 3         12×12×12, 64         3×3×3, 64         3×3×3, 64, (stride 2) ×3           Residual block 4         6×6×6, 64         3×3×3, 64, (stride 2) ×3           Deconv. 1         12×12×12, 128         2×2×2, 64           Residual block 5         3×3×3, 64 ×3           Deconv. 2         24×24×24, 128         2×2×2, 64           Residual block 6         3×3×3, 64 ×3           Output         24×24×24, 3×5         Dropout, p=0.5   | Residual       | 24×24×24, 64  | $\int 3\times 3\times 3$ , 64                               |
| block 3  Residual block 4  Deconv. 1  Residual block 5  Deconv. 2  Residual block 6  Deconv. 2  Residual block 6  Cutput  Data of the proportion of the prop | block 2        |               | $3\times3\times3$ , 64, (stride 2) $\times2$                |
| Residual block 4         6×6×6, 64         3×3×3, 64 (stride 2) ×3           Deconv. 1         12×12×12, 128         2×2×2, 64           Residual block 5         12×12×12, 64 (3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3, 64) (3×3×3×3×3, 64) (3×3×3×3×3×3×3×3×3×3×3×3×3×3×3×3×3×3×3×   | Residual       | 12×12×12, 64  | ∫3×3×3, 64  |
| block 4  Deconv. 1  12×12×12, 128  2×2×2, 64  Residual block 5  Deconv. 2  24×24×24, 128  Residual block 6  Output  24×24×24, 3×5  Dropout, p=0.5  | block 3        |               | $\sqrt{3\times3\times3}$ , 64, (stride 2) $\sqrt{5\times3}$ |
| Deconv. 1         12×12×12, 128         2×2×2, 64           Residual block 5         12×12×12, 64         3×3×3, 64 ×3           Deconv. 2         24×24×24, 128         2×2×2, 64           Residual block 6         24×24×24, 64         3×3×3, 64 ×3           Output         24×24×24, 3×5         Dropout, p=0.5  | Residual       | 6×6×6, 64     | ∫3×3×3, 64  |
| Residual block 5         12×12×12, 64         3×3×3, 64  | block 4        |               | $3\times3\times3$ , 64, (stride 2) $5\times3$               |
| block 5  | Deconv. 1      | 12×12×12, 128 | 2×2×2, 64   |
| Deconv. 2         24×24×24, 128         2×2×2, 64           Residual block 6         24×24×24, 64         3×3×3, 64 ×3           Output         24×24×24, 3×5         Dropout, p=0.5   | Residual       | 12×12×12, 64  | [3×3×3, 64]   |
| Residual block 6         24×24×24, 64         3×3×3, 64         3×3×3, 64         3×3×3, 64         >×3           Output         24×24×24, 3×5         Dropout, p=0.5  | block 5        |               | \(\frac{3}{3}\times 3, 64\)\(\frac{1}{3}\times 3            |
| block 6 3×3×3, 64 ×3 Output 24×24×24, 3×5 Dropout, p=0.5   | Deconv. 2      | 24×24×24, 128 | 2×2×2, 64   |
| Output 24×24×24, 3×5 Dropout, p=0.5  | Residual       | 24×24×24, 64  | ʃ3×3×3, 64 <sub>1</sub>                                     |
| 1 / 1  | block 6        |               | \[3\times3\times3, 64\]\[\times3\]                          |
| 1×1×1, 64  | Output         | 24×24×24, 3×5 | Dropout, p=0.5  |
|  |                |               | $1\times1\times1$ , 64                                      |

| $1 \times 1 \times 1, 15$ |  |  | 1×1×1, 15 |
|---------------------------|--|--|-----------|
|---------------------------|--|--|-----------|

### 4. Detailed network structure for Deep 3D Dual Path Net in Nodule Classification

We design 3D dual path network with 92 layers for nodule classification.

| Hodule Class | incation.                     |  |
|--------------|-------------------------------|--|
| Stage        | Output                        | Weights  |
| Pre-dual     | 32×32×32, 64                  | 3×3×3, 64  |
| path         | ·                             | ·  |
| Dual path    | $32 \times 32 \times 32, 320$ | $[1\times1\times1,96]$   |
| block 1      |                               | $\langle 3 \times 3 \times 3, 96, \text{ (stride 2)} \rangle \times 3$ |
|              |                               | \(\lambda \times 1 \times 1, 272\)                                     |
| Dual path    | $16 \times 16 \times 16,672$  | <sub>1</sub> /1×1×1, 192   |
| block 2      |                               | $\langle 3\times 3\times 3, 192, (\text{stride } 2) \times 4 \rangle$  |
|              |                               | [1×1×1, 544]   |
| Dual path    | 8×8×8, 1528                   | $[1\times1\times1,384]$  |
| block 3      |                               | $3\times3\times3$ , 72, (stride 2) $\times20$                          |
|              |                               | \(\lambda_{1\times1, 1048}\)   |
| Dual path    | $4 \times 4 \times 4$ , 2560  | $\int 1 \times 1 \times 1$ , 768                                       |
| block 4      |                               | $\langle 3\times 3\times 3, 768, (\text{stride } 2) \times 3 \rangle$  |
|              |                               | \(\lambda \times 1 \times 1, 2176 \)                                   |
| Output       | 2560                          | 3D average pool  |
|              | 2                             | 2560×2   |

#### References

- [1] Y. Chen, J. Li, H. Xiao, X. Jin, S. Yan, and J. Feng. "Dual path networks." In Advances in Neural Information Processing Systems, pp. 4468-4476. 2017.
- [2] K. He, X. Zhang, S. Ren, and J. Sun. "Deep residual learning for image recognition." In Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 770-778. 2016.
- [3] F. Liao, M. Li, Z. Li, X. Hu, and S. Song. "Evaluate the Malignancy of Pulmonary Nodules Using the 3D Deep Leaky Noisy-or Network." arXiv preprint arXiv:1711.08324 (2017).