On the Receptive Field of
Dilated Point Convolutions

Francis Engelmann* Theodora Kontogianni* Bastian Leibe
Computer Vision Group, Visual Computing Institute, RWTH Aachen University, Germany

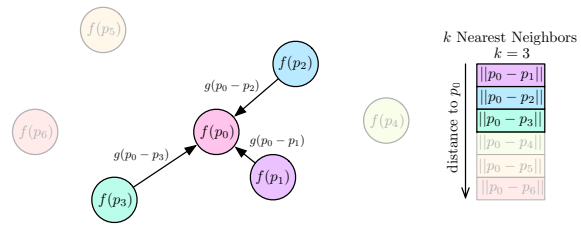
Project Page: www.vision.rwth-aachen.de/page/dpc

In this work, we propose *Dilated Point Convolutions (DPC)* to drastically increase the receptive field of convolutions on 3D point clouds. In particular, we highlight the importance of the receptive field size and propose multiple strategies to increase the receptive field of point convolutions. We compare different network architectures and propose a straightforward network architecture of stacked DPCs.

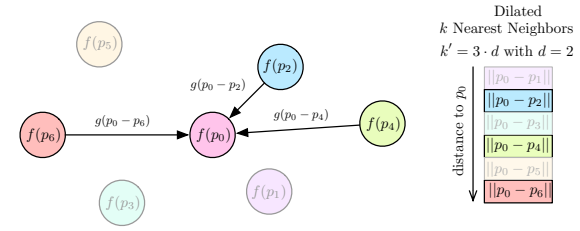
Contributions

- Dilated Point Convolution (DPC)
- Simple network architecture based on DPCs
- Competitive scores on S3DIS and ScanNet
- Easy to add DPCs to your own point network!

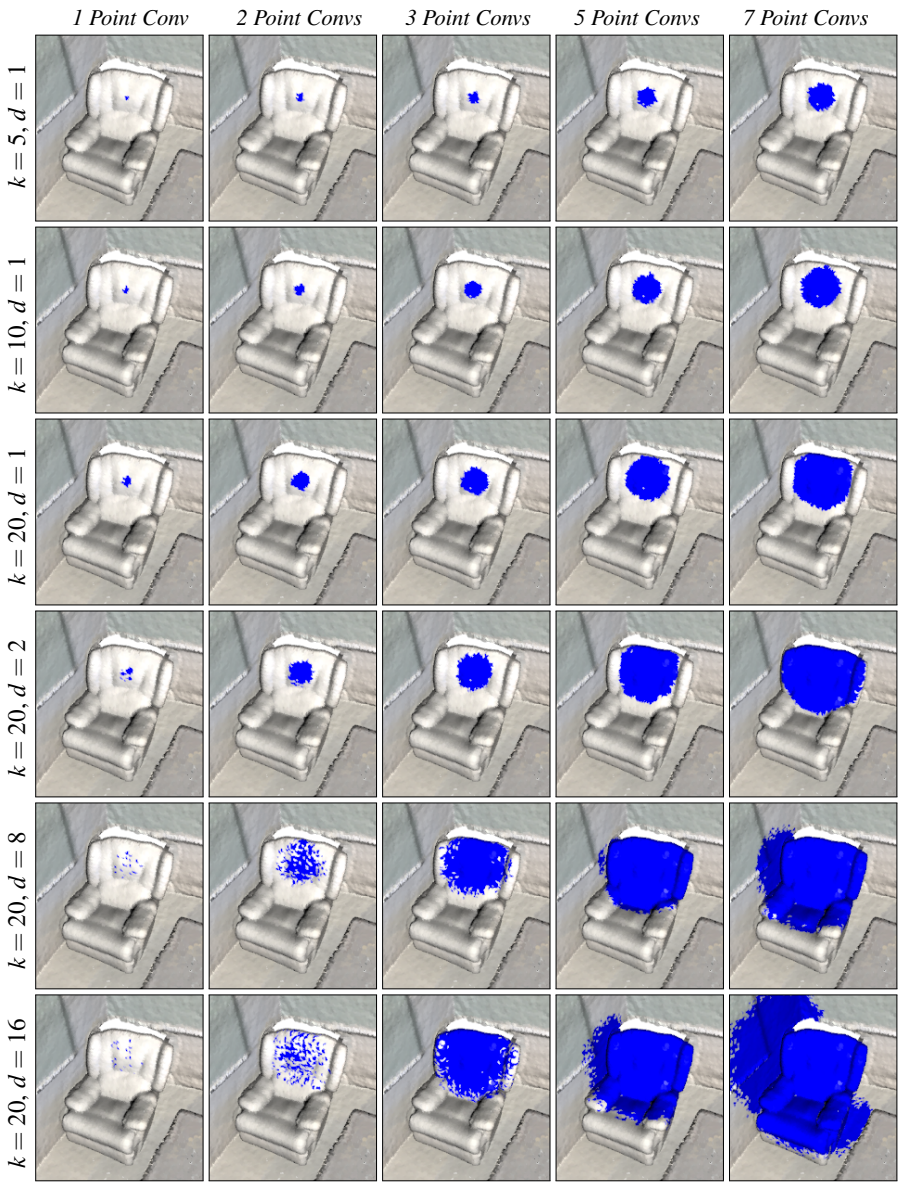
Point Convolutions



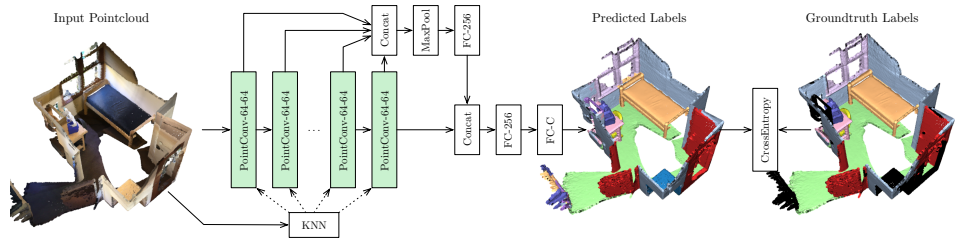
Dilated Point Convolutions



Receptive Field



Architecture



Ablation Study

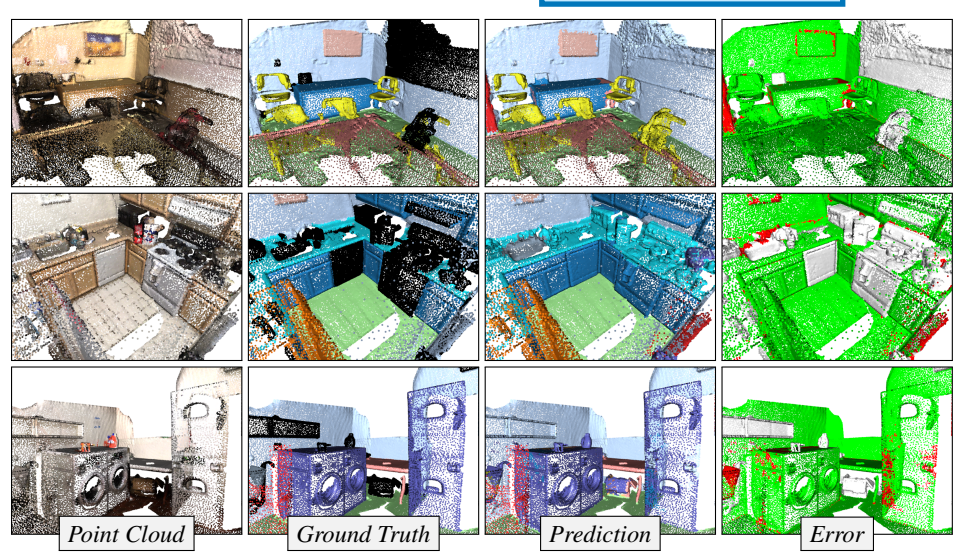
Number of Point Convs	Number of Neighbors k	Time per Forward-Pass	Number of Parameters	Dilation d	mIoU	mAcc	oAcc
7	20	29.38 ms	$880 \cdot 10^3$	1	53.93	61.73	85.58
7	20	31.57 ms	$880 \cdot 10^3$	2	55.83	61.76	85.68
7	20	35.36 ms	$880 \cdot 10^3$	8	**61.28**	**68.38**	**86.78**
7	20	51.65 ms	$880 \cdot 10^3$	16	58.79	65.84	86.41

Number of Point Convs	Number of Neighbors k	Time per Forward-Pass	Number of Parameters	mIoU	mAcc	oAcc
3	5	12.10 ms	$402 \cdot 10^3$	50.04	57.42	**85.01**
3	10	13.64 ms	$402 \cdot 10^3$	50.98	58.16	84.74
3	20	17.65 ms	$402 \cdot 10^3$	**52.25**	**60.83**	84.69
5	5	14.53 ms	$625 \cdot 10^3$	52.69	58.87	**85.33**
5	10	17.12 ms	$625 \cdot 10^3$	52.91	59.57	85.27
5	20	23.35 ms	$625 \cdot 10^3$	**53.27**	**60.15**	85.15
7	5	16.99 ms	$880 \cdot 10^3$	52.93	59.87	**85.62**
7	10	20.68 ms	$880 \cdot 10^3$	53.57	60.92	85.59
7	20	29.38 ms	$880 \cdot 10^3$	**53.93**	**61.73**	85.58

S3DIS A5 Results

Method	mIoU	mAcc	oAcc
PointNet [17]	41.1	49.0	-
Engelmann et al. [6]	52.2	59.1	84.2
PointCNN [12]	57.3	63.9	85.9
SPG [13]	58.0	66.5	86.4
PCNN [21]	58.3	67.0	-
DPC (Ours)	**61.28**	**68.38**	**86.78**

ScanNet Benchmark Results **DPC 59.2 % mIoU**



[6] Engelmann et al. Know What Your Neighbors Do: 3D Semantic Segmentation, ECCVW'18.
[12] Li et al. PointCNN: Convolution On X-Transformed Points, NIPS'18.
[13] Landrieu and Simonovsky: Large-scale Point Cloud Semantic Segmentation with Superpoint Graphs, CVPR'18.
[17] Qi et al. PointNet: Deep Learning on Point Sets for 3D Classification and Segmentation, CVPR'17.
[21] Wang et al. Deep Parametric Continuous Convolutional Neural Networks, CVPR'18.

This project was funded by the ERC Consolidator Grant *DeeViSe* (ERC-2017-CoG-773161)

Computer Vision Group, Visual Computing Institute
RWTH Aachen University
Mies-van-der-Rohe-Str. 15, D-52074 Aachen, Germany.
http://www.vision.rwth-aachen.de