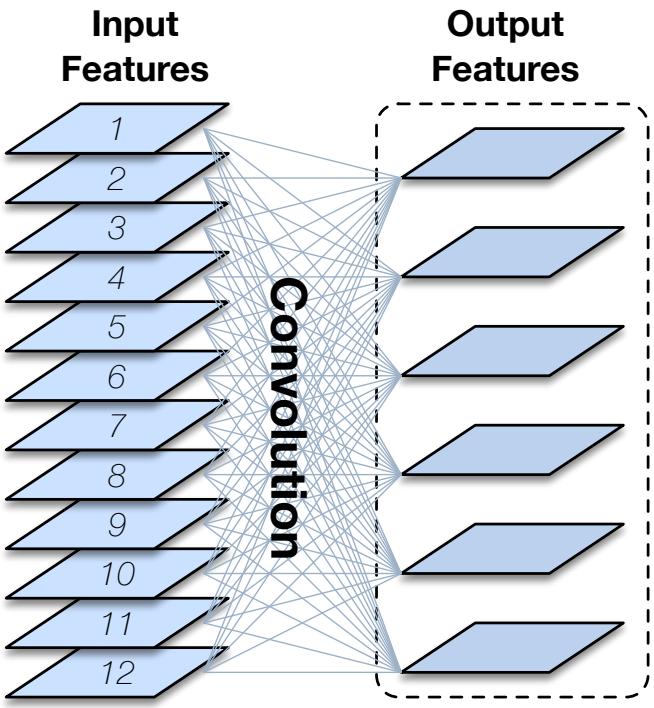
Advanced Topics in Machine Learning: Convolutional Networks (Part 3)

Laurens van der Maaten and Anton Bakhtin

Group Convolutions

- In **group convolutions**, not all input channels feed into all output channels



Group Convolutions

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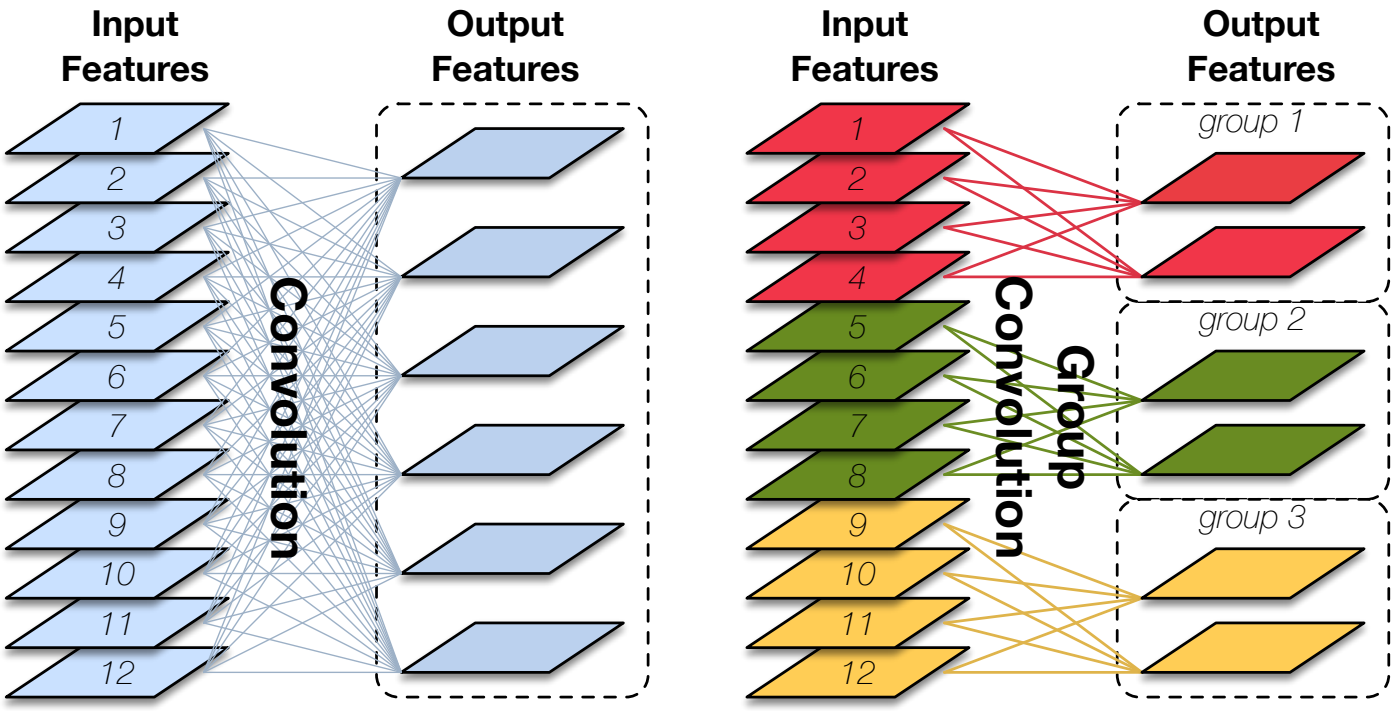
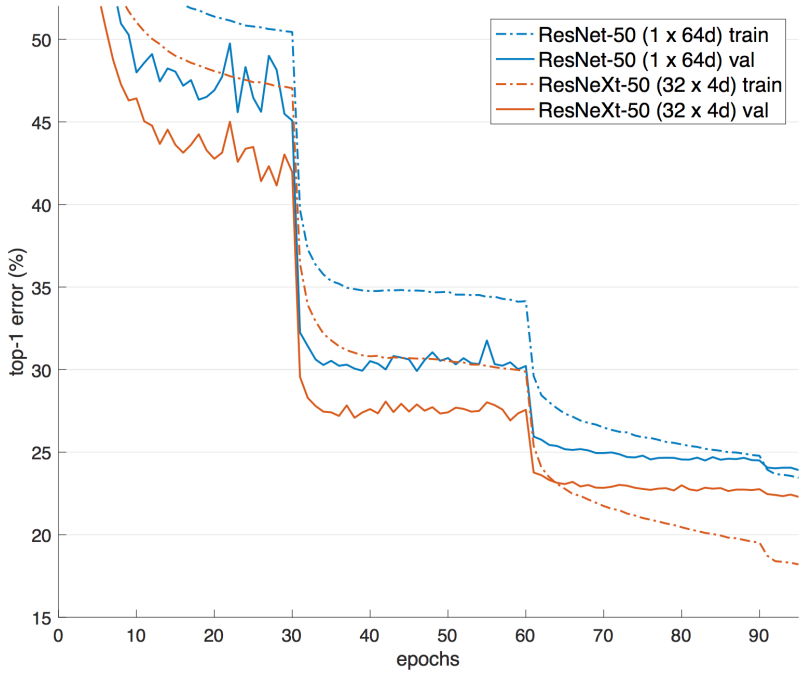


Group Convolutions

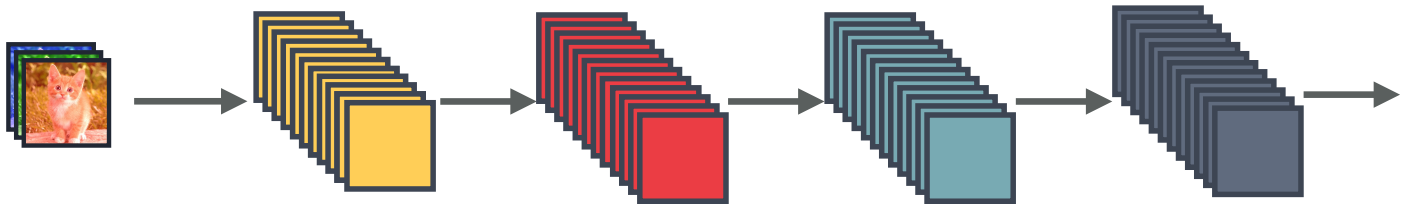
- **ResNeXt** is a popular model that uses group convolutions

- Group convolutions generally give a better **compute-accuracy trade-off**



* Figure credit: Kaiming He

Standard connectivity

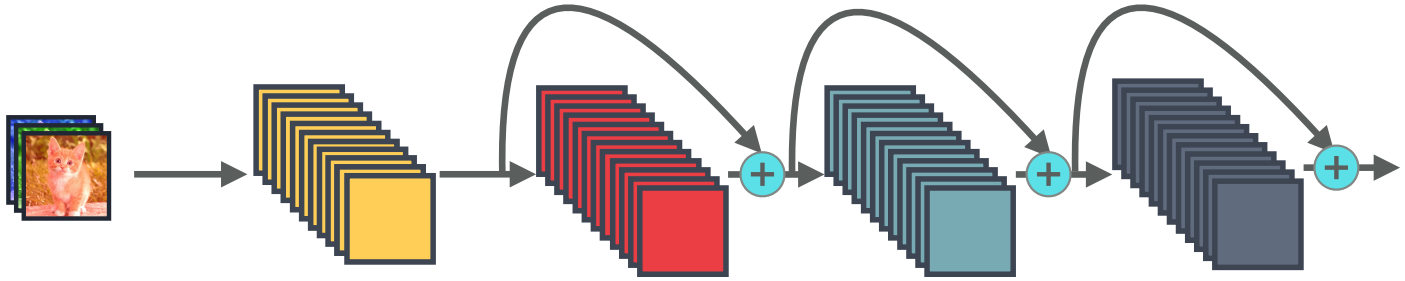


* Slide credits: Gao Huang

Residual connectivity: A new property

Identity mappings promote forward propagation

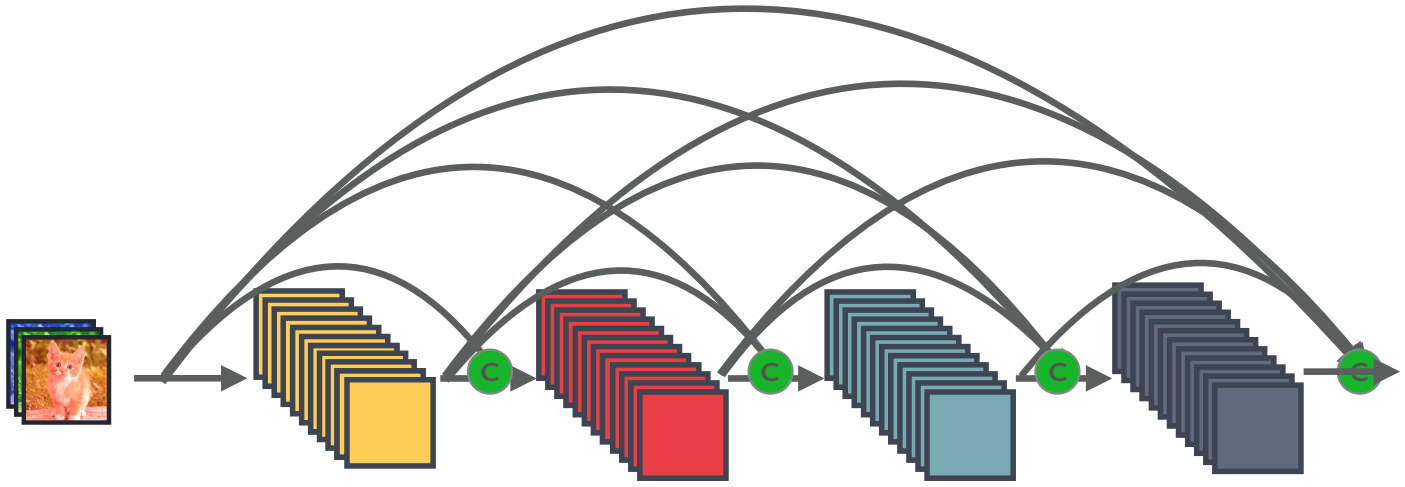
Funny properties of ResNets...



⊕ : Element-wise addition

* Slide credits: Gao Huang

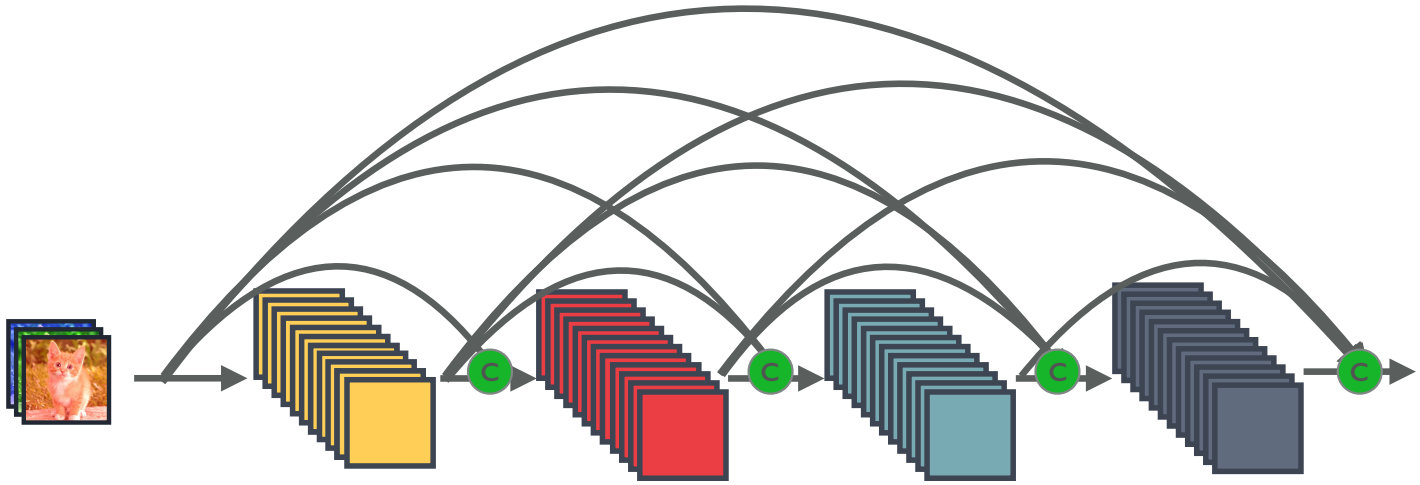
Dense connectivity: DenseNet



C : Channel-wise concatenation

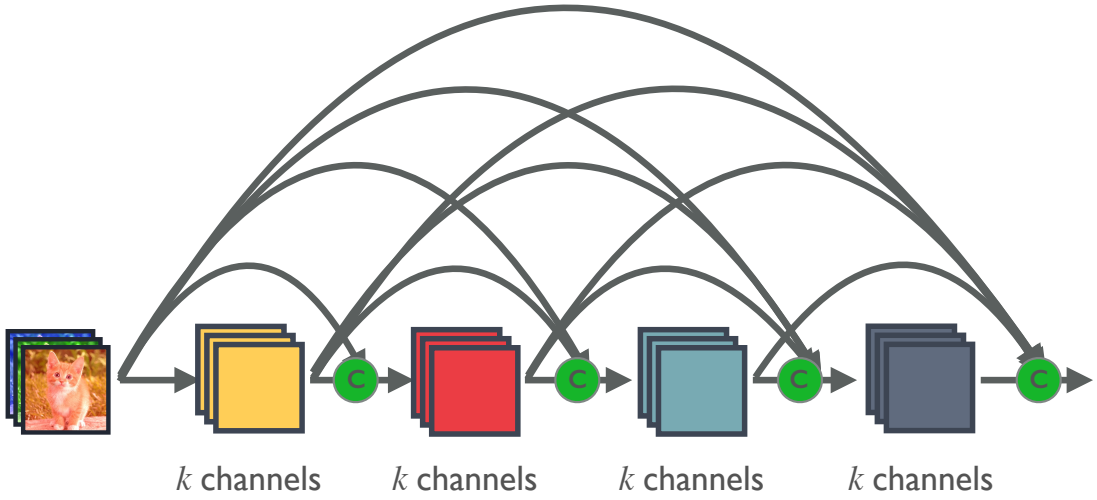
* Slide credits: Gao Huang

Dense connectivity: DenseNet



* Slide credits: Gao Huang

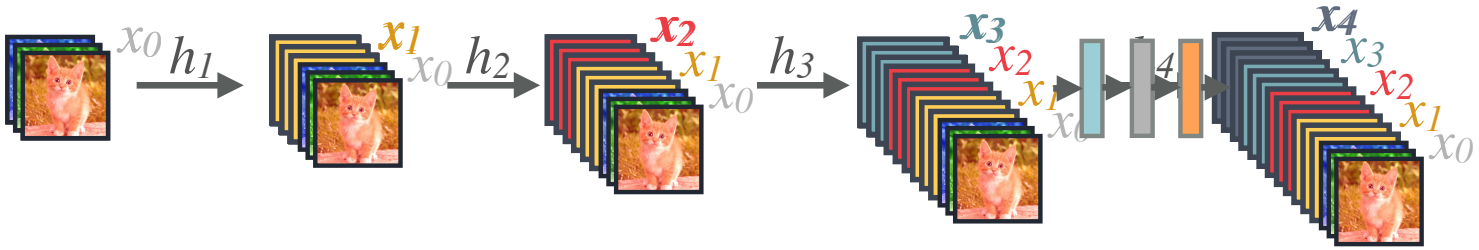
Dense connectivity: DenseNet



k : Growth Rate

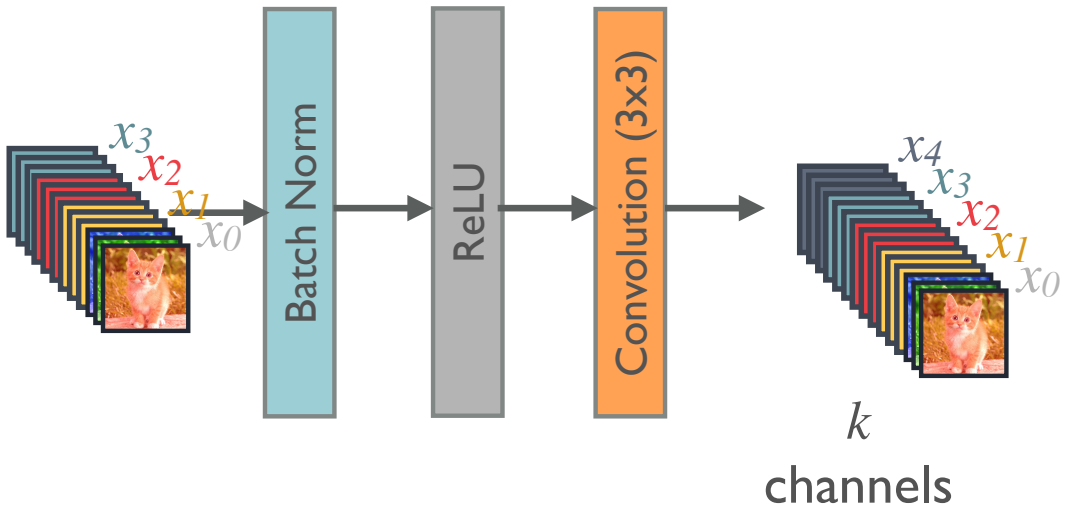
* Slide credits: Gao Huang

Forward propagation



* Slide credits: Gao Huang

Composite layer in DenseNet

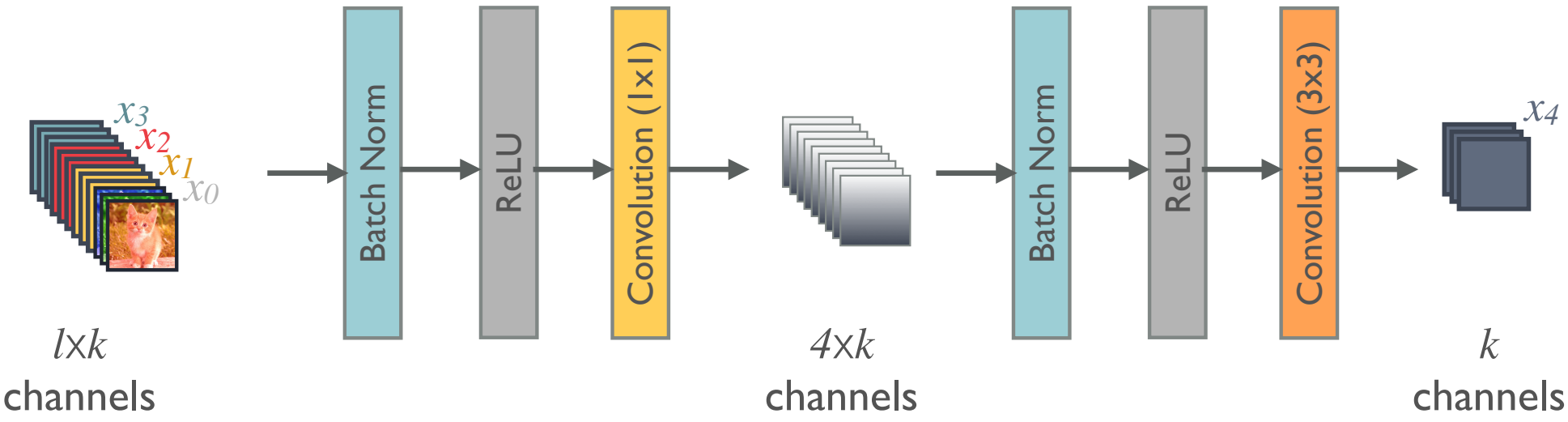


$$x_5 = h_5([x_0, \ldots, x_4])$$

* Slide credits: Gao Huang

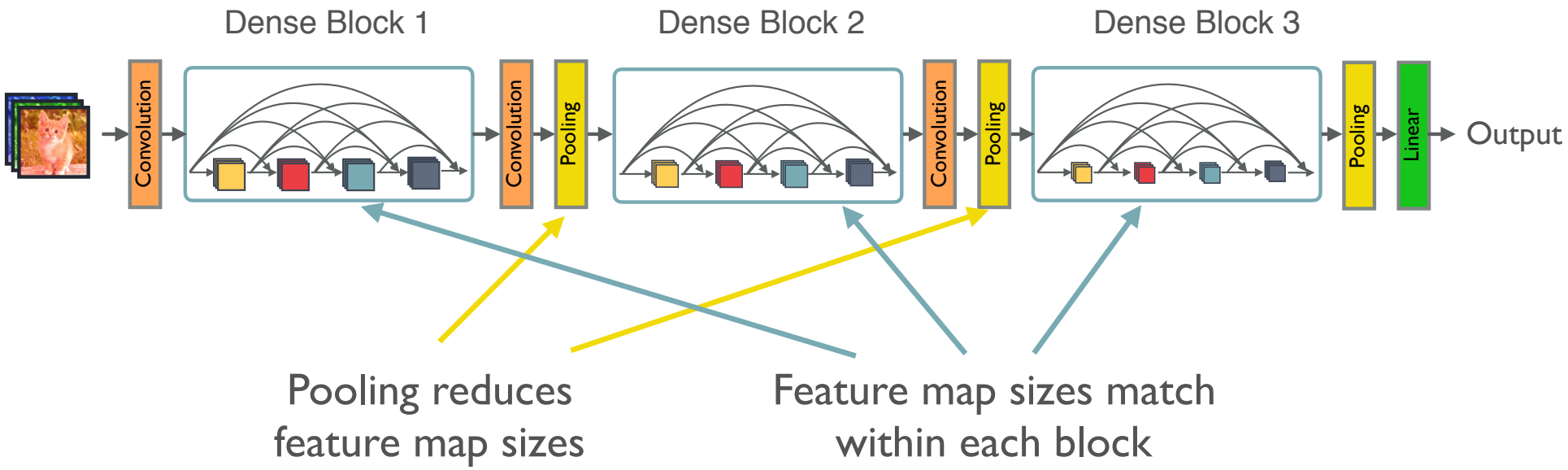
Composite layer in DenseNet

With bottleneck layer:



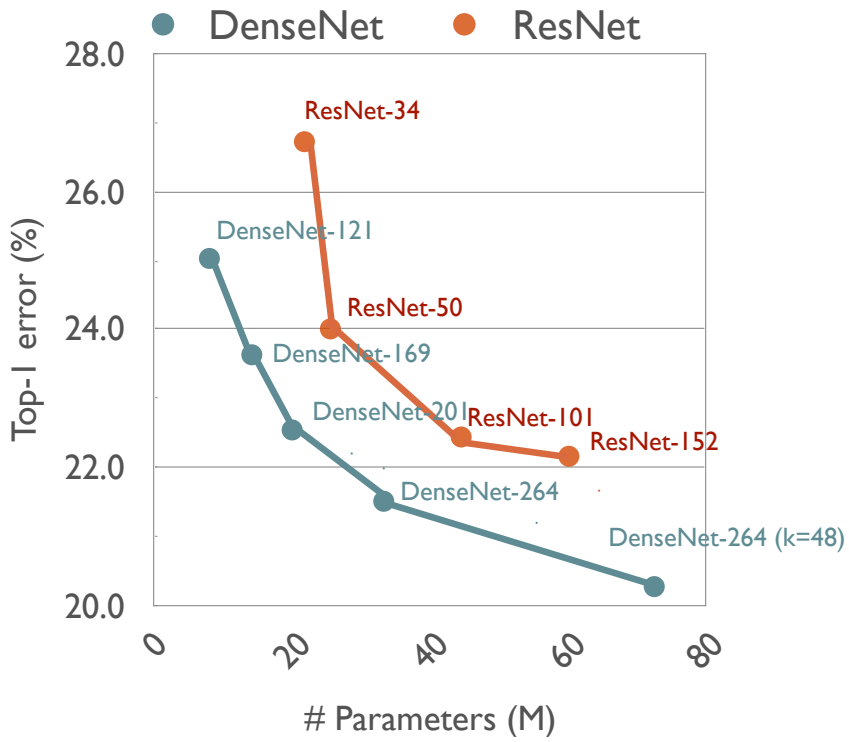
* Slide credits: Gao Huang

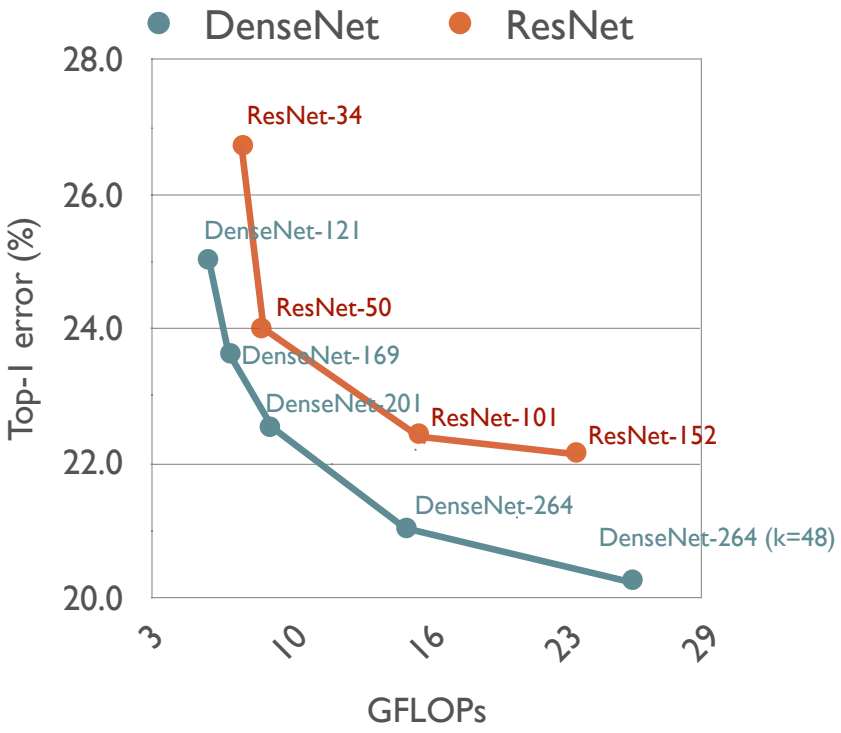
DenseNet



* Slide credits: Gao Huang

Results: ImageNet





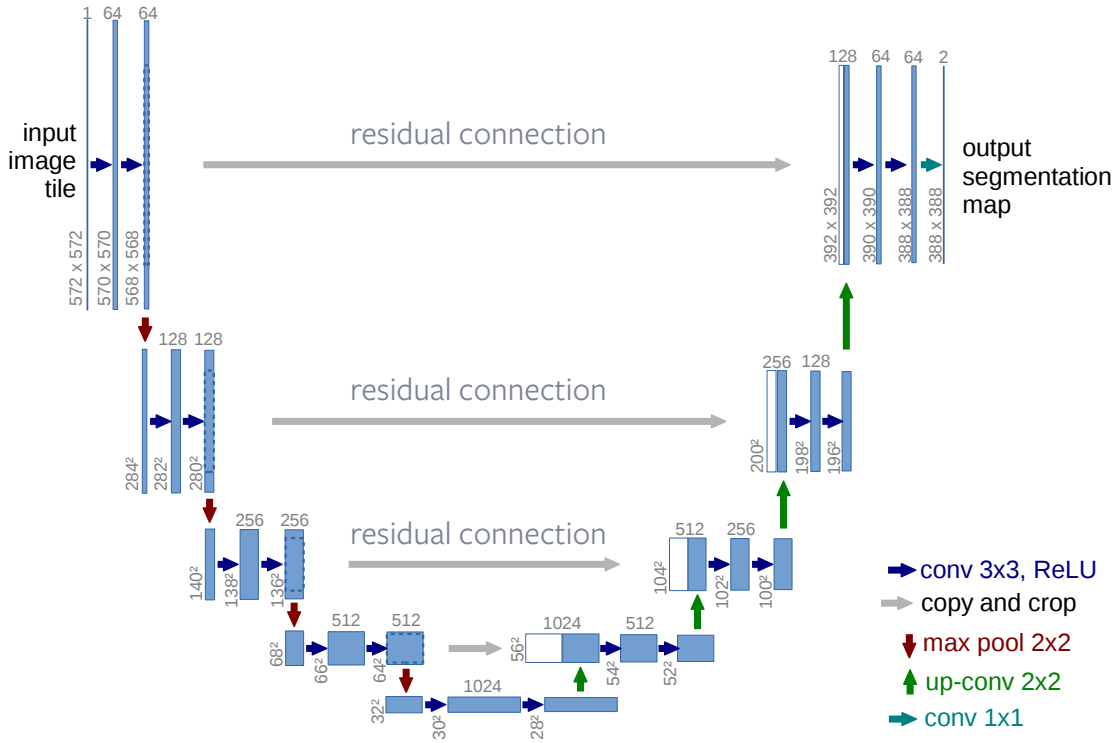
* Slide credits: Gao Huang

Beyond image classification

- **Semantic segmentation**: Predict label for each pixel in the image

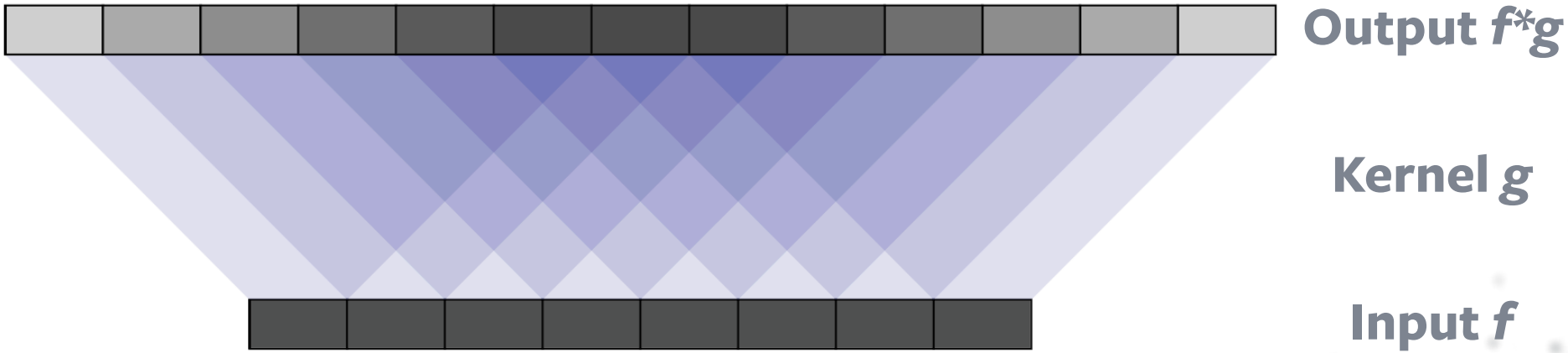
Beyond image classification

- **U-Nets** are an architecture designed for such problems:

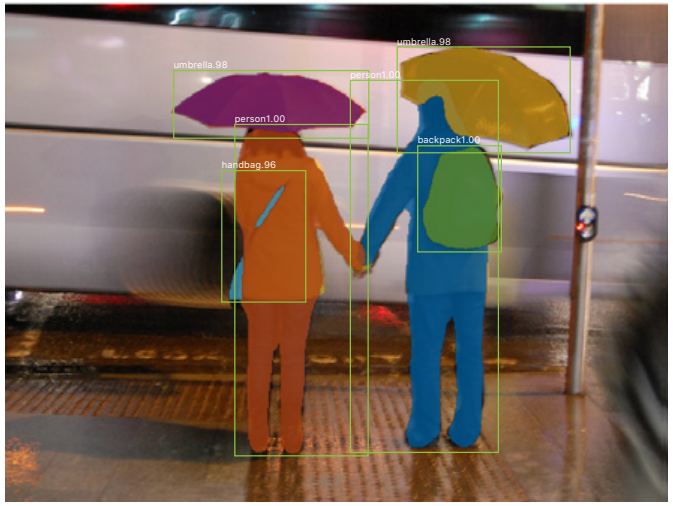


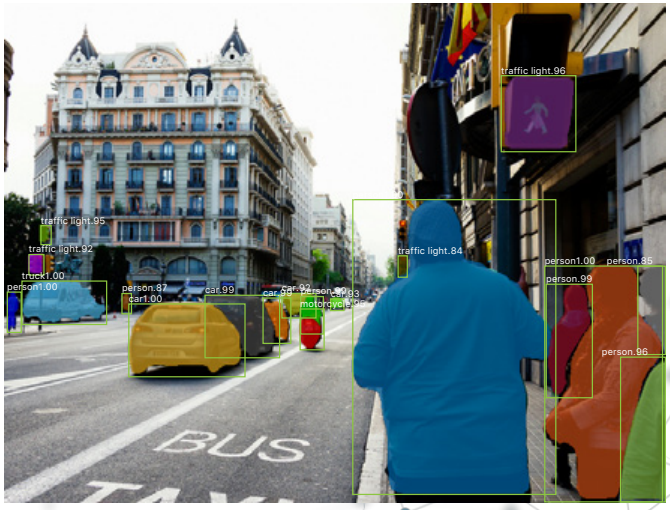
Beyond image classification

- Main additional ingredient in U-Nets is **deconvolution**:



* Credits: Chris Olah





* Results obtained with Mask R-CNN.

Summary

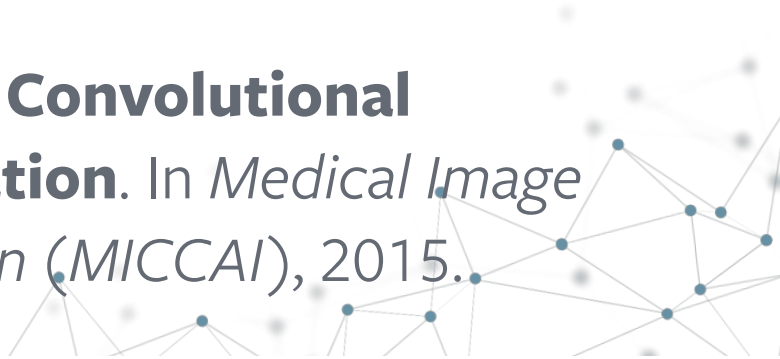
- Dense connectivity is an efficient alternative to residual connectivity
- Group convolutions reduce parameters and computation by reducing number of interactions between input and output channels
- Deconvolution allows for building segmentation networks

Reading material

- S. Xie, R. Girshick, P. Dollár, Z. Tu, and K. He. **Aggregated Residual Transformations for Deep Neural Networks**. In *IEEE Conference on Computer Vision and Pattern Recognition* (*CVPR*), 2017

- G. Huang, Z. Liu, L.J.P. van der Maaten, and K.Q. Weinberger. **Densely Connected Convolutional Networks**. In *IEEE Conference on Computer Vision and Pattern Recognition* (*CVPR*), 2017.

- O. Ronneberger, P. Fischer, and T. Brox. **U-Net: Convolutional Networks for Biomedical Image Segmentation**. In *Medical Image Computing and Computer-Assisted Intervention* (*MICCAI*), 2015.



Questions?