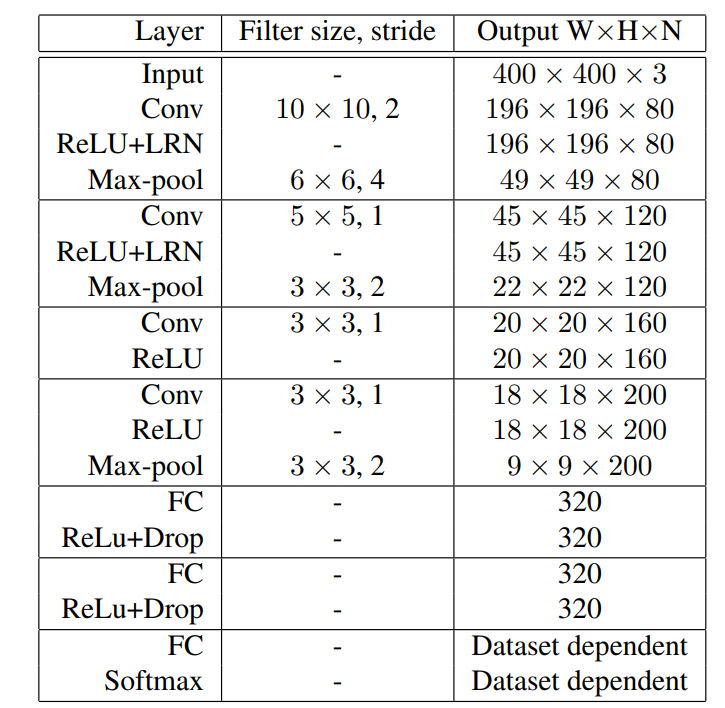
**Zelfstudie – Main project – 09-03-2022**

*Door: Myrthe Boone*

Opdracht : (literatuur) onderzoek over hoe een neural network kan worden gemaakt voor image recognition van histology patches

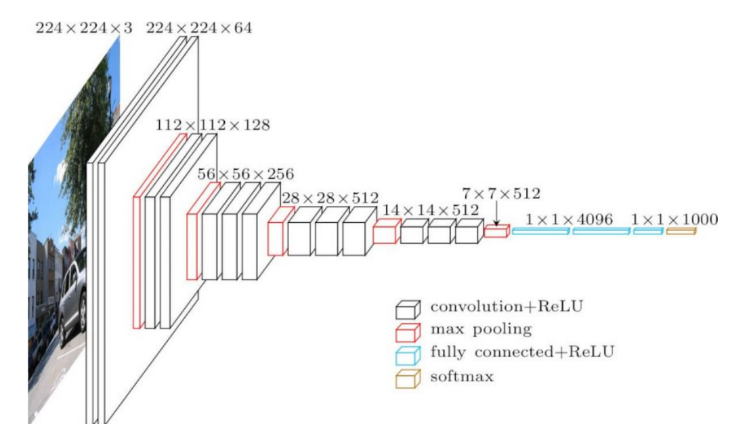
**Pretrained CNN / literature CNNs**

Overview of neural network used for image recognition of gliomas and Non-Small-Cell Lung Carcinoma (NSCLC) from the TCGA dataset [1]



**Question:** If we use a pretrained CNN (and change some layers / output layer), it is a type of transfer learning right? But I thought they indicated in assignment 4 that we do not have to use transfer learning?

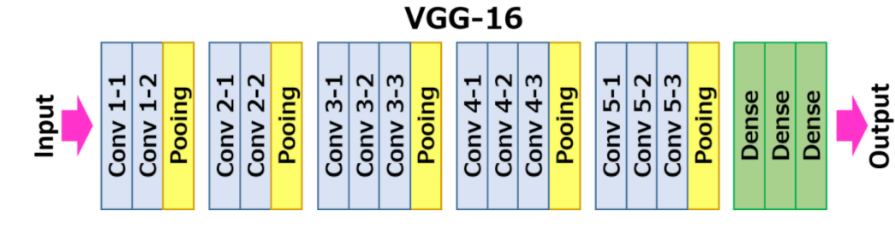
**Answer by Lieke 😊:** Transfer learning means that you use a different data set to pre-train your model. So using an already existing model and training it with our own data is not transfer learning.

**Pretrained networks [2] (artikel komt uit augustus 2020)**

1. **VGG-16**

* Sequential in nature and uses a lot of filters
* 138 billion parameters, slower and much larger model to train than the others

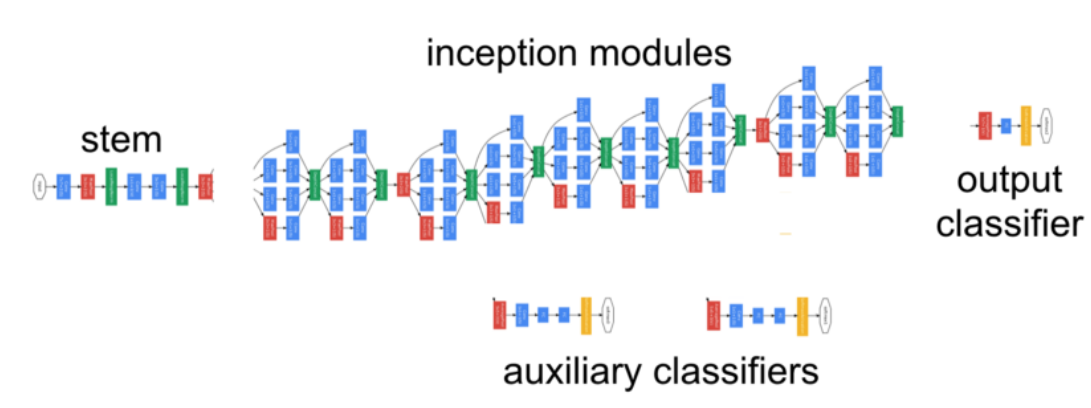
Architecture:

Can be directly imported from keras

Paper on VGG: <https://arxiv.org/pdf/1409.1556.pdf>

1. **GoogLeNet / Inception**

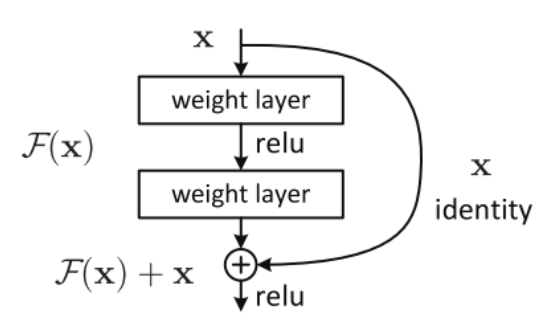
* Only 7 million parameters, smaller dan VGG and AlexNet
* Lower error rate
* Convolutions with different filter sizes on the input, performs Max Pooling, and concatenates the result for the next Inception module.
* The introduction of the 1 \* 1 convolution operation reduces the parameters drastically.
* 22 layers but reduction in number of parameters makes it a difficult model to beat
* Newest version:



Paper on inception: <https://arxiv.org/pdf/1512.00567v3.pdf>

1. **ResNet50**

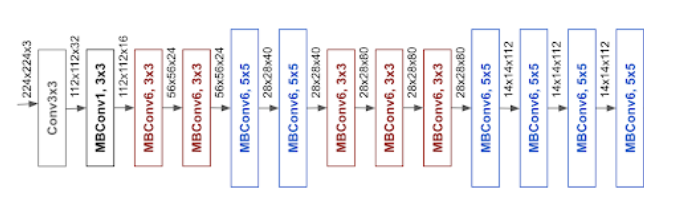
* Aims to tackle the vanishing gradient issue
* Main concept: after every two layers we bypass / skip the layer in between
  + Skipped connections are called ‘identity shortcut connections’ 🡪 uses the residual blocks
* Assumption / proposition: fitting a residual mapping much easier than fitting the actual mapping and thus apply it in all the layers
* Another notion of the authors: the more layers we stack, the model should not perform worse
  + Contrary to Inception and almost similar to VGG16 🡪 just ‘stacking layers’ on top of each other
* Top 5 error rate of 5%
* Squeeze and excitation block? Mentioned by other researchers using ResNet for image recognition (related to cancer)
* Series of architectures based on ResNet (not necessarily other versions but inspiration from ResNet) :



Paper on ResNet: <https://arxiv.org/pdf/1512.03385v1.pdf>

1. **EfficientNet (Google again)**

* New scaling method: compound scaling
  + Conventional approach: scale dimensions arbitrarily and by adding up more and more layers
  + New approach: scale dimensions by a fixed amount at the same time and do so uniformly 🡪 much better performance
* Scaling technique can be used for any CNN model
* Compound scaling formula
* Has to be installed separately via pip install in anaconda before it can be used
* Used in EfficientNetB0:



Paper on EfficientNet:

<https://arxiv.org/pdf/1905.11946.pdf>

**Additional tips and ideas ideas to improve existing neural networks / work further with model from assignment 3**

* Cross validation
* Image augmentation (if dataset is too small but what is too small?)
* Use fixed random seed [3]
* Start simple (e.g. save data augmentation and regularization for later)
  + “ E.g. if you are classifying images don’t be a hero and just copy paste a ResNet-50 for your first run. You’re allowed to do something more custom later and beat this.” [3]
  + So good idea to start with ResNet 😊
* Use Adam optimization algorithm (safe to start with, method for stochastic optimization)
* Only when we have a good understanding of how the network works, and which optimization algorithm we want to use we can go further with the next steps
  + Data augmentation
    - Data augmentation is another way of regularization which is used to reduce overfitting of models by an increase in the amount of training data using the present original information only. (transformation, TensorLayer) [R]
  + Regularization
  + Drop out layers
  + Use pretrained model
  + Decrease batch size
  + Random grid search + hyper parameter optimization

**Question**: is an exisiting CNN architecture (ResNet e.g. ) also a pretrained network or is that something different?

**Answer from Lieke 😊:** I think a pretrained model is the same as transfer learning.

*Things to think about*

* Which optimizer do we want to use?
* We can also use an existing architecture ‘module’ so not the whole neural network but use parts of it and then add our own (activation) layers.
* Preprocessing of the images? (smoothing, data augmentation, zero-centering and normalization of intensity for smooth variation of the intensity over the tissues ) [R]

**Bibliography**

[1]

<https://www.cv-foundation.org/openaccess/content_cvpr_2016/papers/Hou_Patch-Based_Convolutional_Neural_CVPR_2016_paper.pdf>

[2] <https://www.analyticsvidhya.com/blog/2020/08/top-4-pre-trained-models-for-image-classification-with-python-code/>

[3] <http://karpathy.github.io/2019/04/25/recipe/>

[B] <https://arxiv.org/abs/1703.02442>

*(****Newly added 10-03-2022 by Myrthe****)*

*We also found that several approaches yielded no benefits: (1) a multi-scale approach that mimics the human cognition of a pathologist’s examination of biological tissue, (2****) pretraining the model on ImageNet image recognition****, and (3) color normalization*. [B]

*The Camelyon16 challenge winner [1] achieved a sensitivity of 75% at 8 FP per slide and a slide-level classification AUC of 92.5% [23].* ***The authors trained a Inception (V1, GoogLeNet)*** *[20] model on a pre-sampled set of image patches, and trained a random forest classifier on 28 hand-engineered features to predict the slide label.* [B]

**Research questions proposal (Myrthe)**

With what accuracy can a convolutional neural network predict the presence of metastases in lymph nodes histological image patches?

* Compare to with what accuracy a doctor it does “For comparison, a human pathologist attempting exhaustive search achieved 73.2% sensitivity”[B]

Compare two neural networks for instance ResNet and EfficientNet or Inception🡪 compute accuracy and compare again with doctor as well.

Inception was used a lot in literature also especially for this challenge (the winner of this challenge used the Inception neural network).

<file:///C:/Users/20192024/Downloads/thesis_michel_kok_s4470613.pdf> (for more scientific references)

**Introduction – why computer aided diagnosis / deep learning for image recognition?**

* Less error-prone
* Less time consuming and tedious than when pathologists have to do it manually
* Experts sometimes disagree with their decisions [Q]
* Inter and intra user variability
* Convolutional neural networks and histological image patches work together since CNNs are able to extract features from the images without the amount of weights increasing exponentially (computationally less expensive than only fully connected layers) and image patches need less storage on processor units etc.
* (Downside of image patches 🡪 peripherals not taken into account [1])
* Early diagnosis and recognition of metastasis in sentinel lymph nodes of breast cancer patients increases chances of survival [Q]
* Current diagnostic methods not good / accurate enough?
* Beneficial for under developed countries with not enough physicians / specialists where they are needed [R]

A biopsy [[8](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214587#pone.0214587.ref008)] is the only diagnostic procedure that can definitely determine if the suspicious area is cancerous. The pathologists diagnose by visual inspection of histological slides under the microscope, which is considered as confirmatory gold standard for diagnosis [[9](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214587#pone.0214587.ref009)] [Q]

It is shown that the use of Computer-aided diagnosis (CAD) [[10](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214587#pone.0214587.ref010)] to automatically classify histopathological images can not only improve the diagnostic efficiency, but also provide doctors with more objective and accurate diagnosis results. [Q]

**Zelfstudie Lieke – Main project – 10-03-22**

I thought it would be helpful to elaborate Myrthe’s SSA by looking into similar project (histological classification) and which neural networks are used as a basis there. I found the following articles:

**Cancer histology detection with Resnet:**

[Q] <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214587>

[R] <https://ieeexplore.ieee.org/abstract/document/8882973?casa_token=8JkR-OaeuvcAAAAA:V3LslMNgSCYlucJNn4FZ-8r1DKBjiuNHacser_pBHBLt3wyT4ZqAiRELH4Gs60wevI8xxp_Y>

<https://link.springer.com/chapter/10.1007/978-3-030-17938-0_19>

<https://towardsdatascience.com/squeeze-and-excitation-networks-9ef5e71eacd7> (info on squeeze and excitation modules used in ResNet)

**VGG**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6775529/>

<https://www.mdpi.com/2077-0383/8/9/1310>

**googLenet**

<https://www.hindawi.com/journals/bmri/2019/1065652/>

<https://link.springer.com/chapter/10.1007/978-3-319-93000-8_94>

**Efficientnet**

<https://www.hindawi.com/journals/cin/2021/5580914/>

<https://www.mdpi.com/2072-6694/13/4/661>

**conclusion**

All of these articles resulted in a decent outcome. Furthermore, I could find multiple articles about each network Myrthe has described. Therefore, I think we could choose from all of the above and we should choose the one we are most comfortable with.

Answer from Myrthe 😊 : I agree!!!