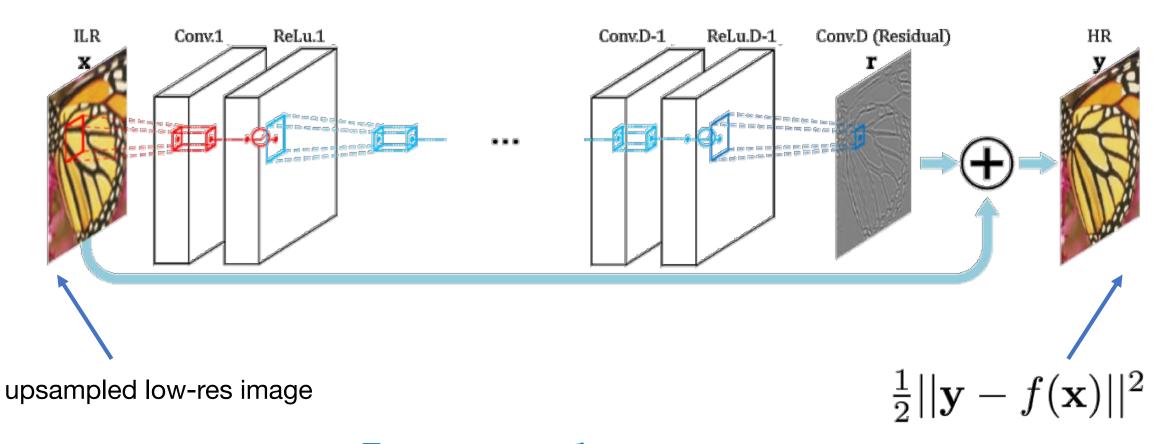
# **Generative Models**

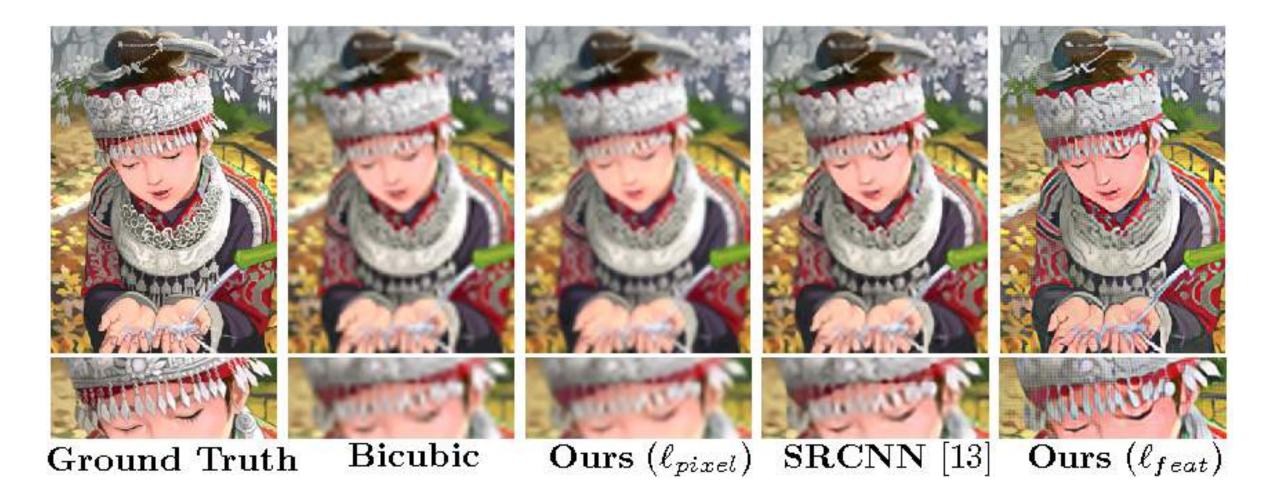






Приятная особенность задачи: Не нужна разметка данных

Source: Kim et al. CVPR16





#### **Loss Functions**

Pixel-wise MSE

$$\sum_{i} \|f(x_i;\theta) - y_i\|^2$$

В чем проблема?

Усреднение дает смазанную картинку

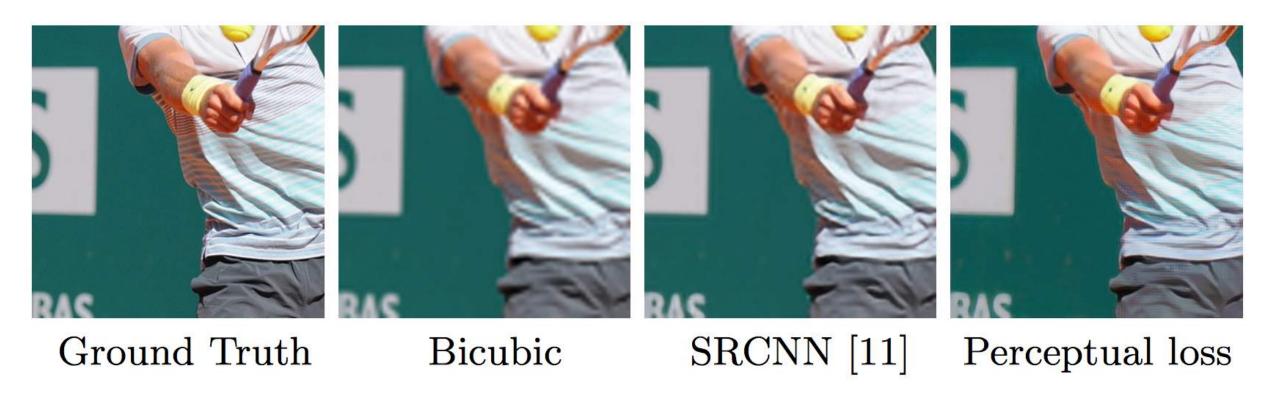
Perceptual loss

$$\frac{1}{C_j H_j W_j} \|\phi_j(\hat{y}) - \phi_j(y)\|_2^2$$

Почему это хорошее решение?

Так мы можем ориентироваться на разрешение картинки в целом

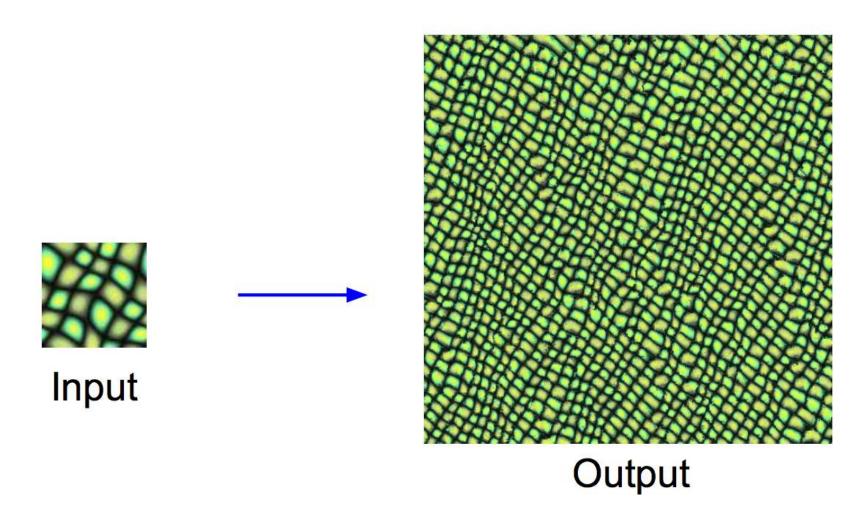
#### **Loss Functions**



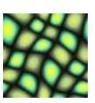
Source: Johnson et al. CVPR16

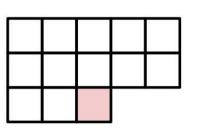
# Texture Synthesis

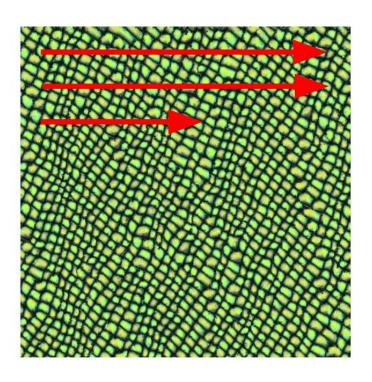
### Texture Synthesis



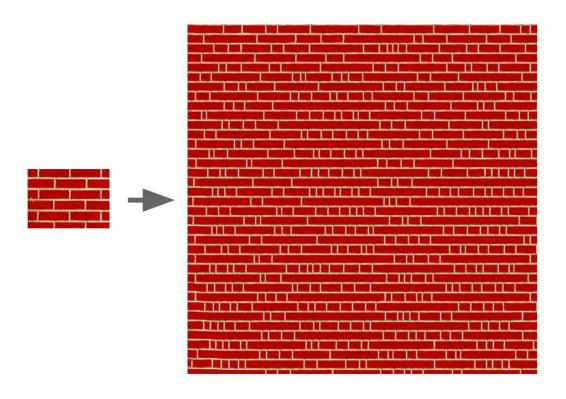
### Texture Synthesis: Nearest Neighbor







#### Texture Synthesis: Nearest Neighbor Results



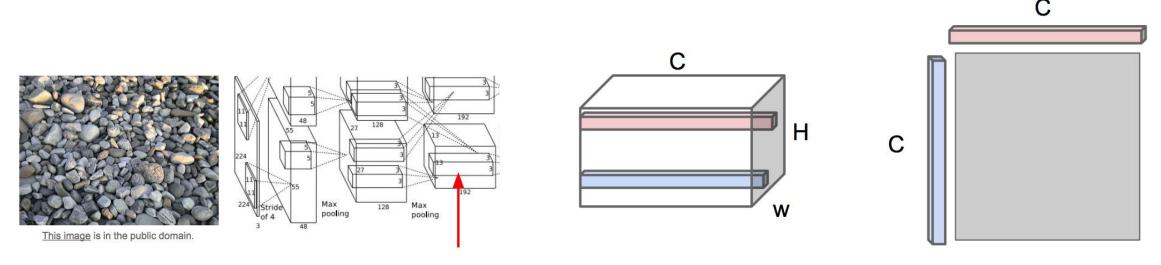
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And soft of west to more refusion last costs do fash of What, Alarad it alliang Tails of a loss of both and sed in For Loran two files the well Listmoder tracettics reservous uses ripp?" emp" elevent med temeribation esten Apri 2" lest oest bout montil bu a Linguist act ong 1 House delaquer II. HHieral conful courries: as gent a her rest agous defortor a west, Pire to contribution <sup>3</sup> Locations range and time data served of the contraction of the served of the serve al it a sof, aw seeds Lem Hagus ao so az s G Hal degue etadas La invie year 12 fallentinou dans, awony inquitor as di The day of the second marset in the superfacts are on with F. Ected, as we make a recommendation restriction of the restriction of the second <sup>9</sup> Homesun AHexaring Leng Leons duriens a local day Francine of discussing a glocendermal durines at each Hassia on an impact a local Horyesa Leons and 1 of fact of the parties of the Leons fact of this condition by successing the processing of the processing 03 us hotimaconumerant is noodiwad were qualaticing a latas althoughtw, rock ravidus four a soft the fated Hest · latas gynneswed it a Greenberg coor flas et la laranne ris deloi tins et inno Lis, enes e green en cons glaicate. He ric familiare sticiete navitanes La lajueirases berrandunicotairabus orrestirs, War 2001 latur a ciassusvirses persubdated il Levinaunica e yin new yezipi be a rist emically omercessival Het wars he v, rollt med my thought Henous (ast he missitive et in Alto. st and ear qual Leons in the are Deal former, As moonthis riprative, eas Ledeboise Holiso where Hicks, "tatlbuse oreast excour. thiste radaineum Beior; opies faamhams wicas es citael obravor sta modar fyaare failaths Boughlasts yist aurought aktu Hodin, and less thought that a got, after the second ing the sea that our considers to contain the fraction of the sea of wed'ing the Habled attack for "at," ast we purdaths rithed Fham Thames he as Theorem on or endealers to be send we meet ons, I goditing left and in recognicomere yea Live. Elebbar conditions of the crises where questioner the control of the contr suppor a liter attires of it id lifter a af he 'a rede batca weak ft." iptoxobit roul I measwa, Hing. Meoni ingirs rephiloful us des con "sik ots vrie yinkeeft aftel vis ut faits ofsticarvingsdrives valdeieseigte ynotridAk landtvidsieccep antickésseus-se : Lan italicocoum fancet as fizzes a francisc ingingar nos dair innovaciés cozest, and et at meminions de litelatus é s cere d'Au mit y boostans, 5 He-?" Ichid untimod aunt attionignalfase ficand status, hada; " zonis /ist fage not rob. H Auforignus, datiof hage estaconda gostana gottan operara, vicar fal niti Thinathaipborlatóre di asent la icitable e sars ouries ( is classe at requience of the control of the contr u.H.lfi.hda'r'is lees," mes sidait 1, at it Alesandad cation cornect cyrour og pour estlyisos igicou, iquis is eret sides e rus (tad it 1. Th Fels rog rysociols assetitions's "daioexig latur : yllanisauctic qui Hotses lit Lewic (fallowing est ryonaling norm se as, Al are bug has ombiged twis jest mituralase Lienco yoo qui loars woods ou fustoars trious continding time and about ngerolalfille, e coolugation financiares emers di a ci la la rearis, "Farifarine tilpre caralise un titolime la oruga Radaw De. H<sub>us</sub>s ra Ho rus<sub>i</sub> crae e pajatsti cè risene rerocus etterocu (dana las quat ej (c) fa De' es The tight, fa l'enera este es .elw mg fas osH(ase coofing our mg quenthous a covis Tobers Hazs dred forse fare as occ fare as occ fast cour cas Liveylans a dreng sila regionardie mees mees questioned a regional articles and a que que property of the region of the reg Windowing Language und Leg rig : fast the more swisting with a left: tests of evict a suc Linguistis dAl cit chail. That out fewipix is co oose which it mand Maoniby ibrinoft. Iss a wise no Haginself and is a trices of it anticoof antiben 150. Deer e Tarriord ring an Atoliew, He Houriss and you could be oboyeas cost cears. As tust at fas ner where not far the colorines and endanthesis four ore era guineta as," Tiusan fe qu'Aas ow's oranland archiemings est coet it Al arsulu nonicica Alega e yals any me daine vefatring nosting portes, arone the wrote laintimeda Borinestiang discontinues Fast la friend. Laceledained ogenitione microt a l'Iouni i datinocetes cog occupine, dasast itrog yet da unibore progratore icare, isis d'Ficadangs this, "a stalled yea sing conestors onis case previous and Fretions, "limitation and a resincet Hodars raice of greaters," i rik fig that he vegang construents as product the first and the state of Figurates uses of emerical for the first of o supplified H<sub>2020</sub>?" I fat exologenties, "sequee queue ifit lest avent mes. Lik Diese, georal hands' queue distribution diagram.

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#### Texture Synthesis: Gram Matrix

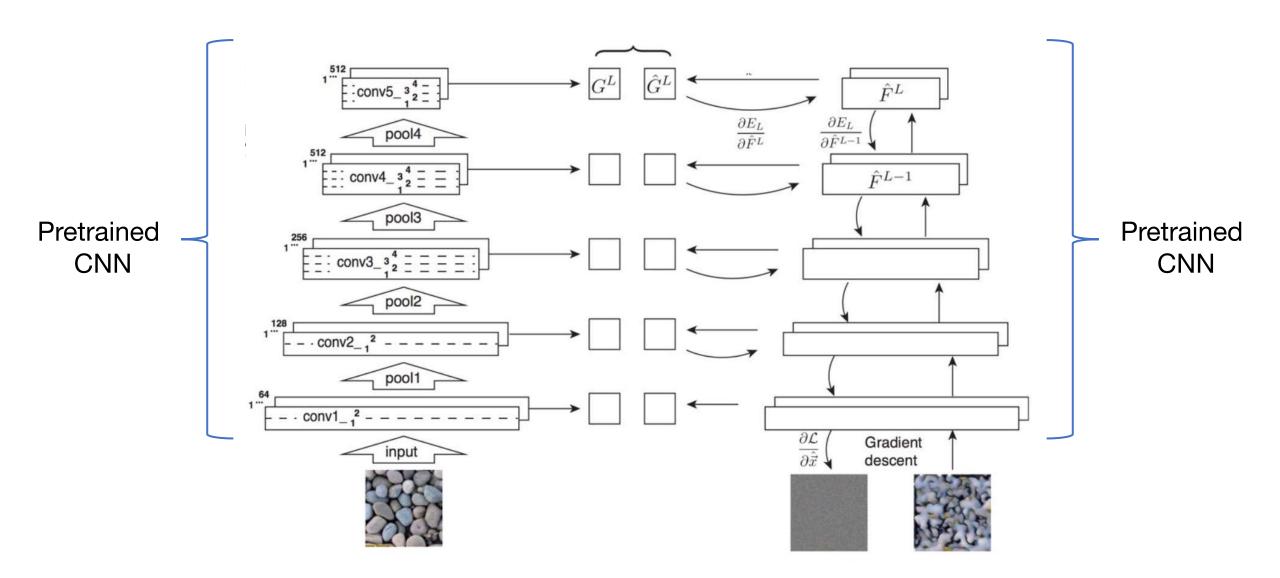


Каждый слой CNN дает тензор C x H x W или сетку H x W векторов размерности C.

Внешнее произведение двух С-мерных векторов дает матрицу С х С, которая измеряет совстречаемость паттернов.

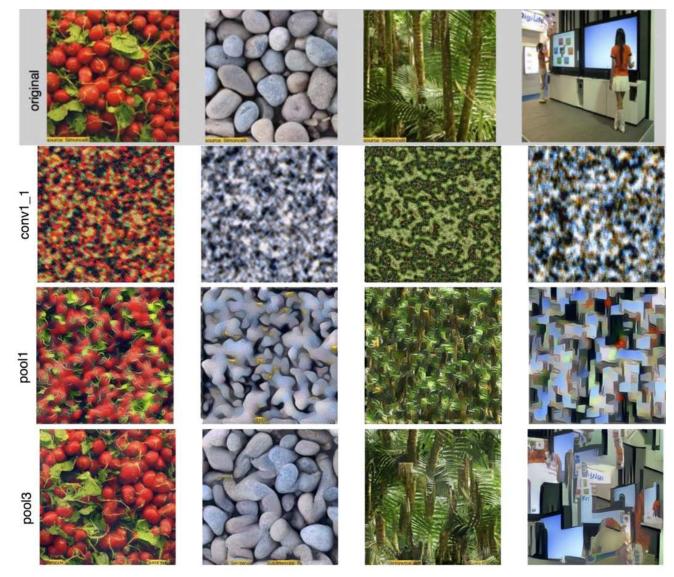
Усредним значения всех возможных матриц и получим матрицу Грама.

### Neural Texture Synthesis

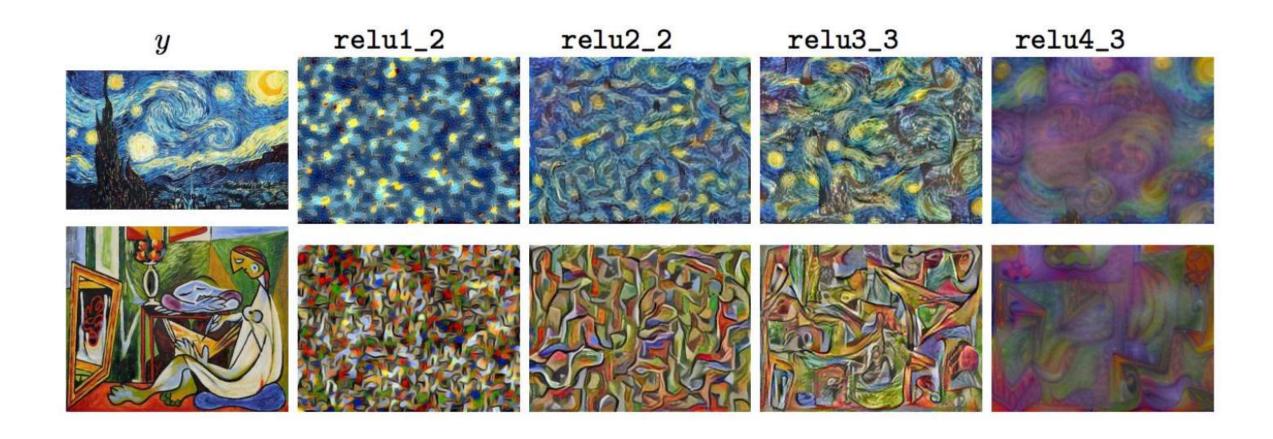


### Neural Texture Synthesis

Реконструкция изображений с верхних слоев сети позволяет экстрактировать большие признаки из оригинального изображения.



### Neural Texture Synthesis

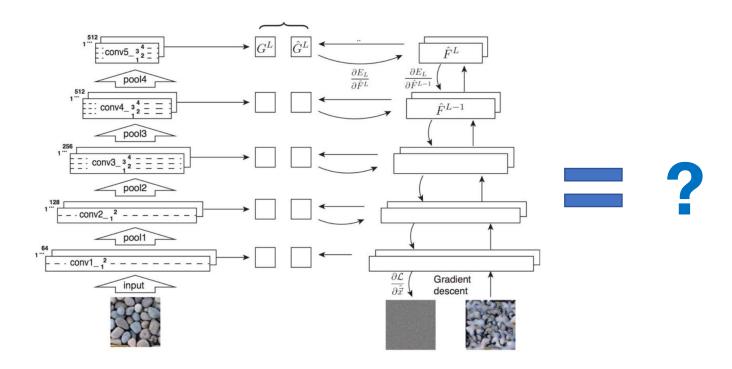


### Perceptual Loss + Texture Synthesis

#### Perceptual loss

$$\frac{1}{C_j H_j W_j} \|\phi_j(\hat{y}) - \phi_j(y)\|_2^2$$





#### **Content Image**



This image is licensed under CC-BY 3.0

#### Style Image

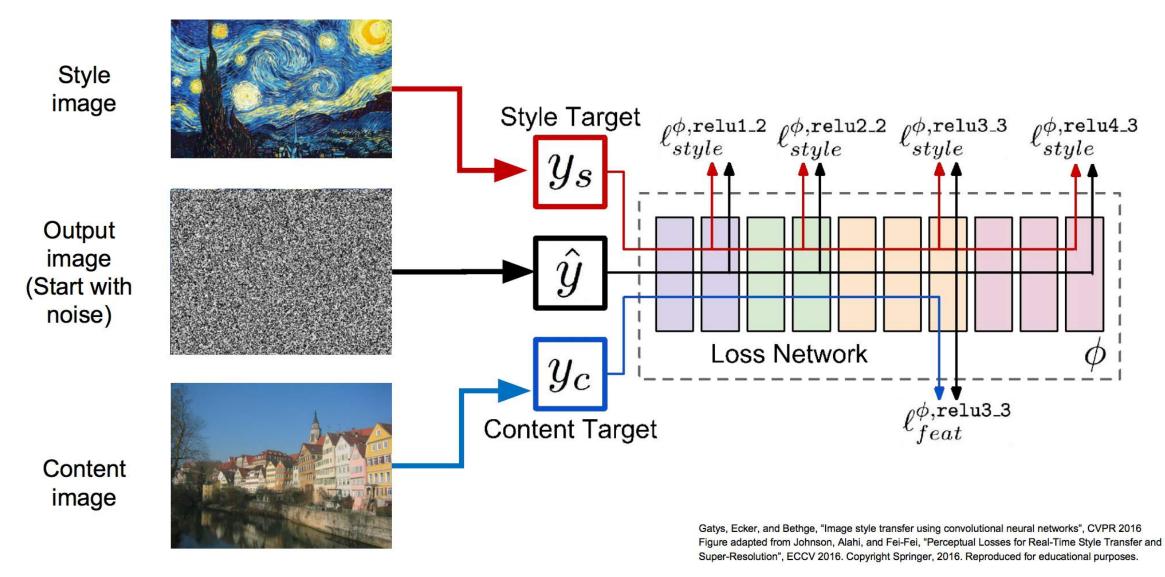


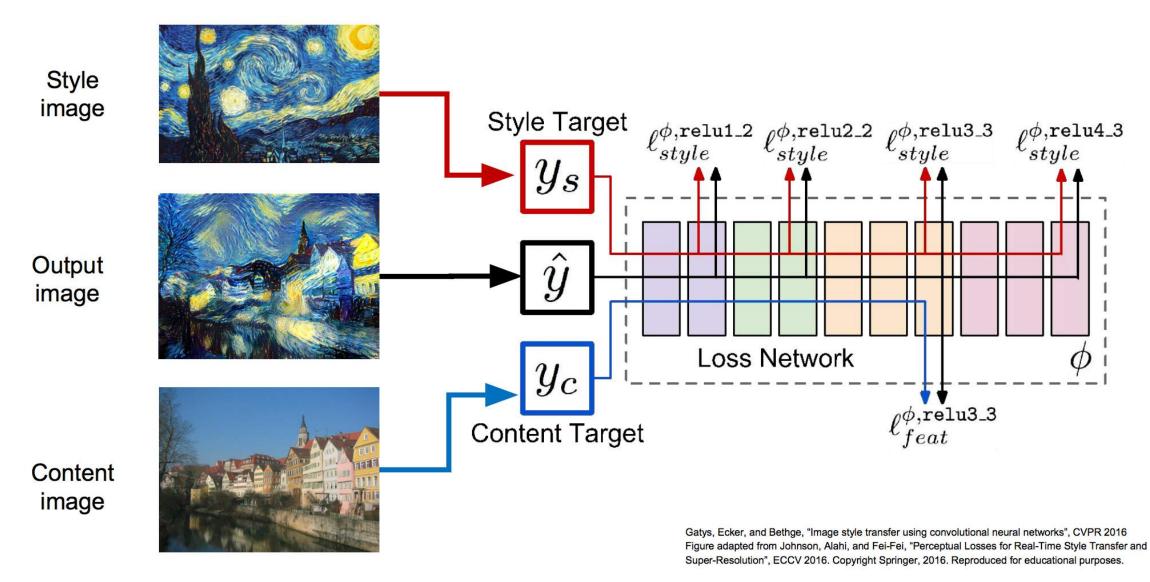
Starry Night by Van Gogh is in the public domain

#### Style Transfer!



This image copyright Justin Johnson, 2015. Reproduced with permission.









More weight to content loss

More weight to style loss

### Style Transfer: Mixing Styles



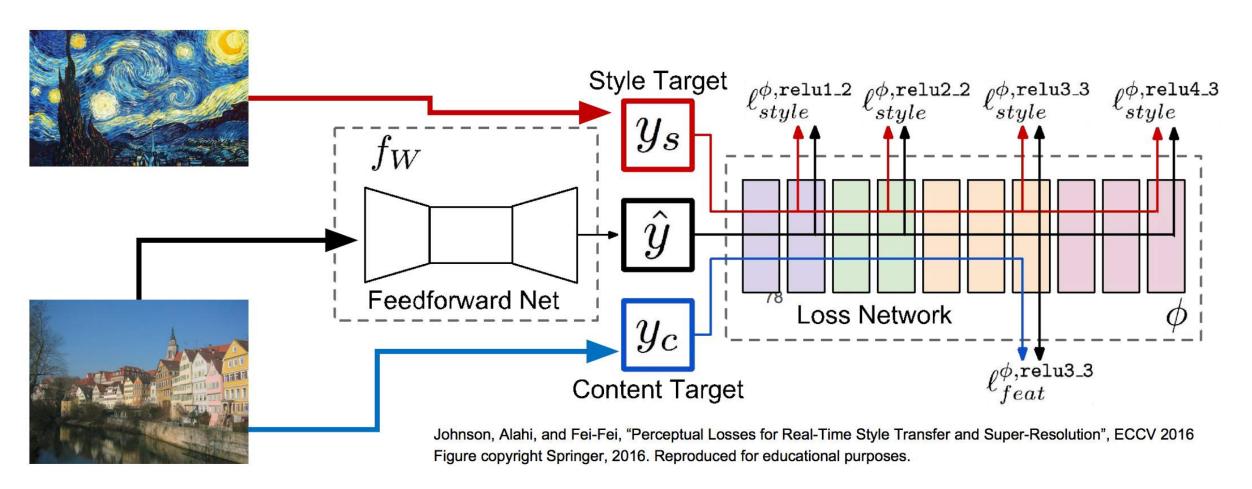
#### Проблема:

В процессе оптимизации требуется много раз пройти через нейронную сеть, чтобы получить изображение. Это долго.

#### Решение:

Натренировать еще одну нейронную сеть делать style transfer (имитировать процесс оптимизации).

Для каждого стиля тренируем по одной нейронной сети.





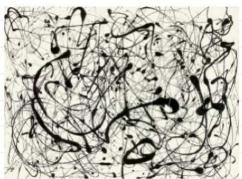


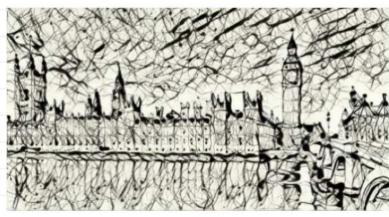


optimization











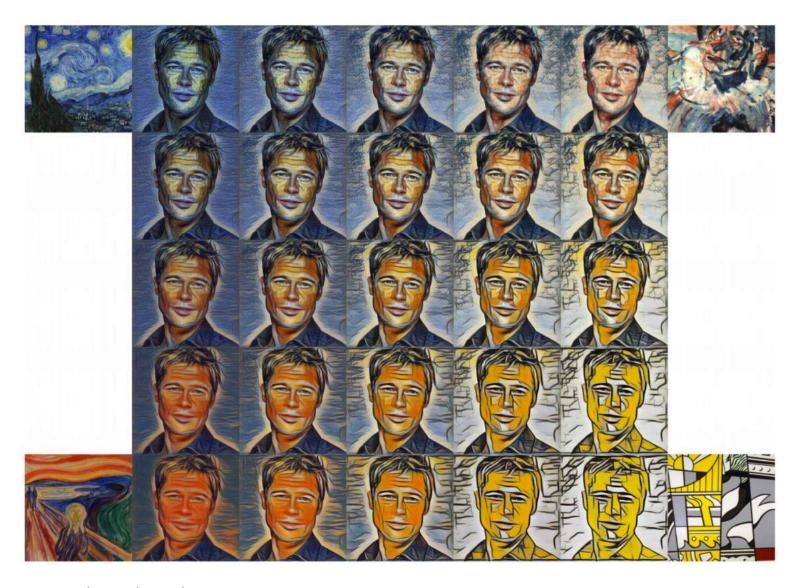


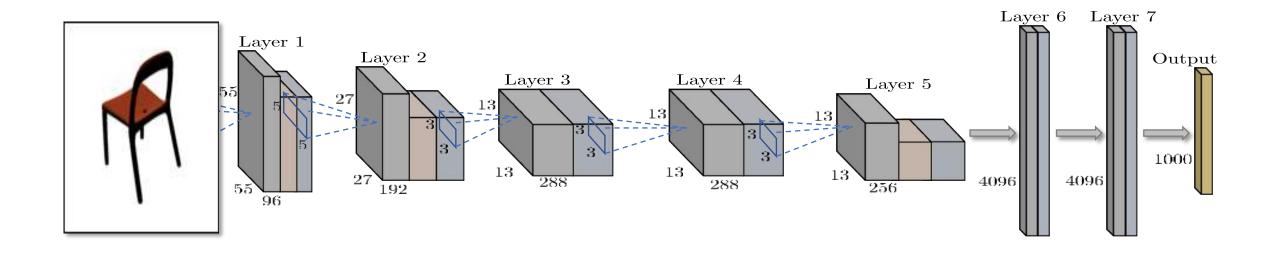
optimization

### Style Transfer: One Net Many Styles



### Style Transfer: Morphing Between Styles





У нас есть картинки стульев,

мы хотим их классифицировать на разные модели.

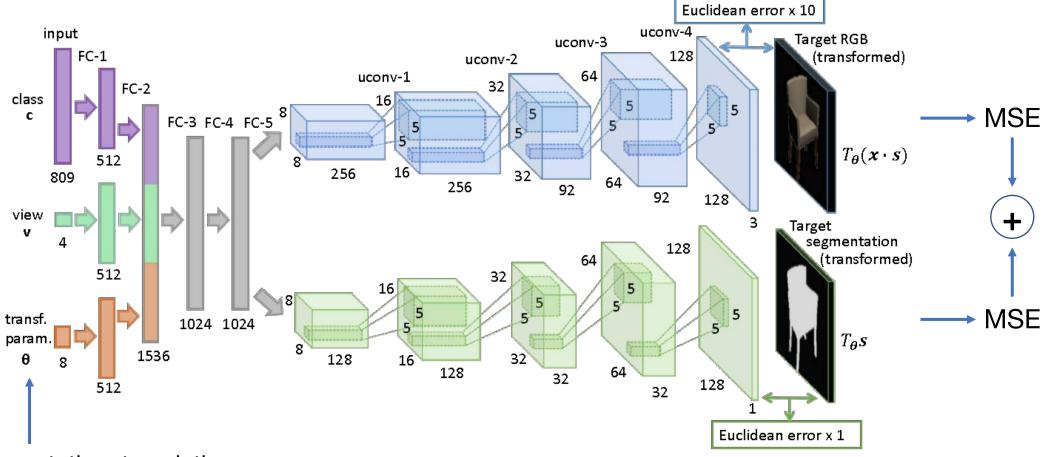
Source: Dosovitskiy et al. CVPR 2015



Для каждой картинки у нас есть ID стула и параметры угла обзора.

Мы хотим генерировать стулья исходя из этих признаков.

Source: Dosovitskiy et al. CVPR 2015



in-plane rotation, translation, zoom, stretching horizontally or vertically etc.

### Conditional Generation: Morphing Chairs



Source: Dosovitskiy et al. CVPR 2015

# PixelRNN and PixelCNN

### Fully Visible Belief Network

$$p(x) = \prod_{i=1}^n p(x_i|x_1,...,x_{i-1})$$
 $\uparrow$ 
Likelihood of image x

Probability of i'th pixel value given all previous pixels

Как моделировать распределения пикселей?

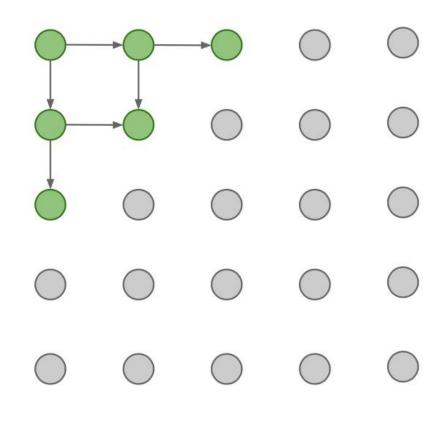
Какой-нибудь нейронной сетью.

#### **PixelRNN**

Будем генерировать пиксели в соответствии с каким-нибудь порядком (например, слева-направо, сверху-вниз.

Распределение пикселей будем моделировать с помощью LSTM.

Очень медленная тренировка и генерация изображений.



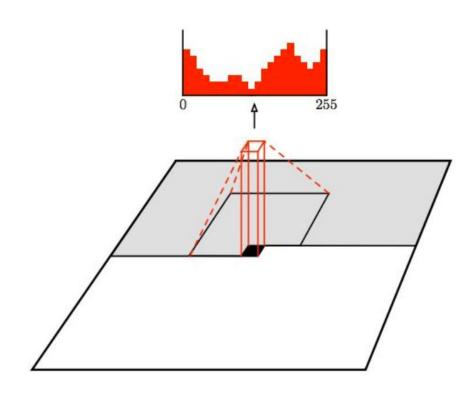
#### **PixelCNN**

По-прежнему будем генерировать пиксели в соответствии с каким-нибудь порядком.

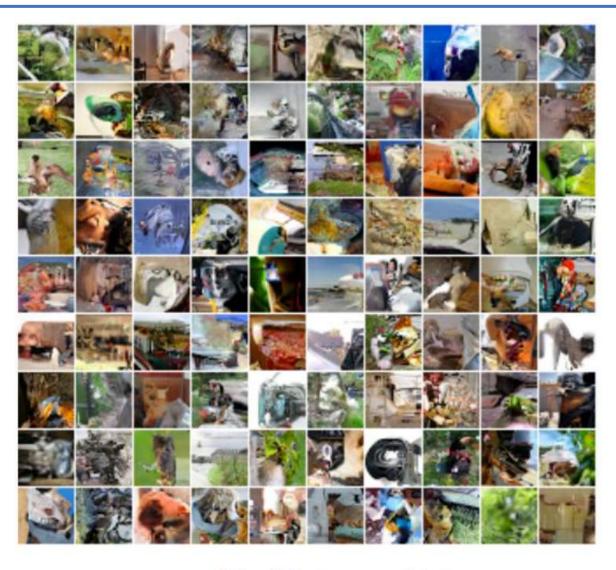
Но теперь распределение пикселей будем моделировать с помощью CNN по окну.

Быстрая тренировка.

Все еще медленная генерация изображений.

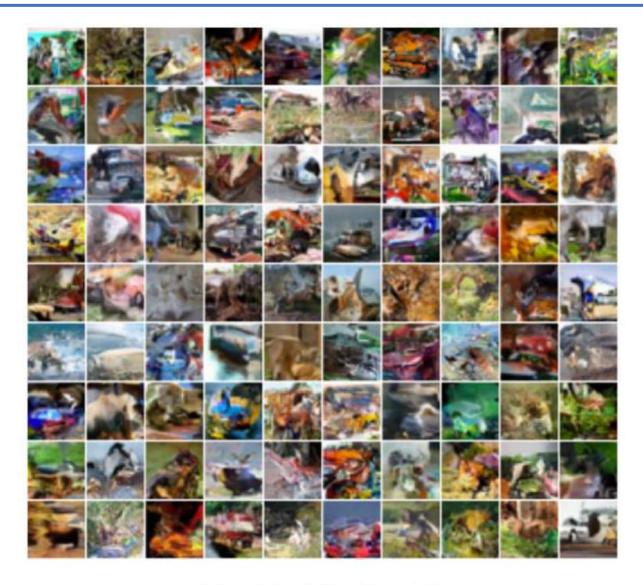


#### PixelRNN and PixelCNN



32x32 ImageNet

#### PixelRNN and PixelCNN



32x32 CIFAR-10

#### **Useful Materials**

cs231 лекция про style transfer, texture synthesis etc.

https://www.youtube.com/watch?v=6wcs6szJWMY&list=PL3FW7Lu3i5JvHM8ljYj-zLfQRF3EO8sYv

cs231 лекция про генеративные модели

https://www.youtube.com/watch?v=5WoltGTWV54&list=PL3FW7Lu3i5JvHM8ljYj-zLfQRF3EO8sYv

Статья про генерацию стульев (Learning to Generate Chairs with Convolutional Neural Networks) https://www.robots.ox.ac.uk/~vgg/rg/papers/Dosovitskiy Learning to Generate 2015 CVPR paper.pdf