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CInC Flow: Characterizable Invertible 3×3 Convolution

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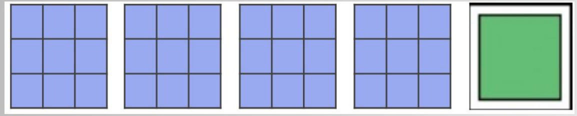
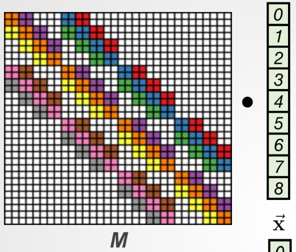
Goal: derive necessary and sufficient conditions on a padded CNN for it to be invertible. also proposed a coupling method.

-- Standard Convolution: $y = M\hat{x}$

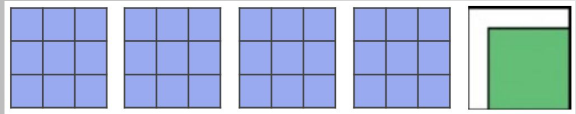
x: input, y: output, M: Convolution matrix



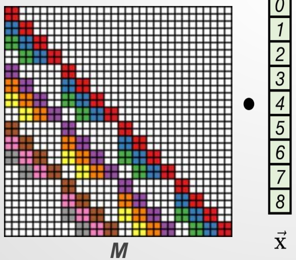
Kernels (3x3) std. padded input (x)



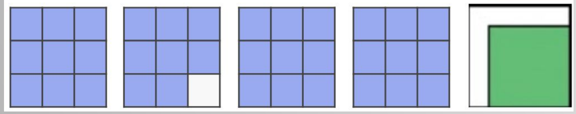
-- Convolution with specific padded input



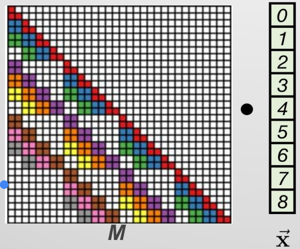
kernels (3x3) input(padded x)



-- Convolution with specific padded input and masked kernels (Proposed method)



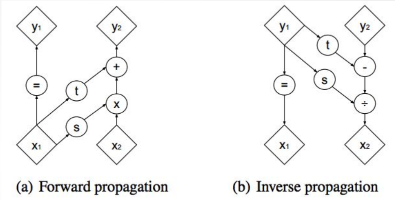
masked kernels (3x3) input(padded x)



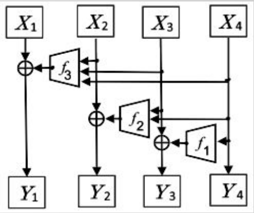
ensure invertibility ← triangular

--Coupling Layers: we propose to use a modified version of the coupling layer designed to have a bigger receptive field.

-Affine Coupling

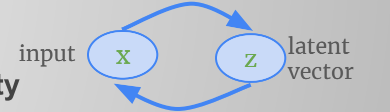


-Quad Coupling (Proposed method)



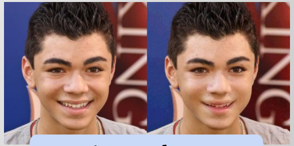
expressive coupling mechanism

--Image generation

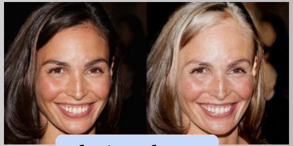


-Interpretability

removing glasses

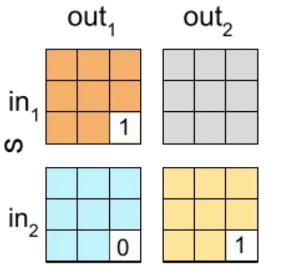
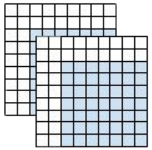
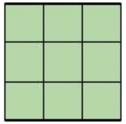
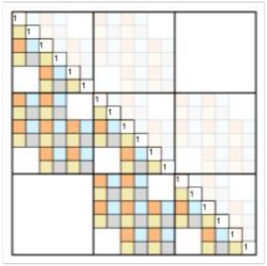
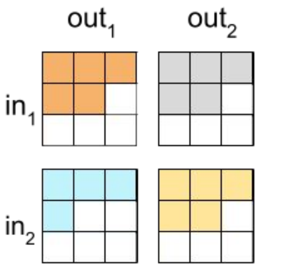
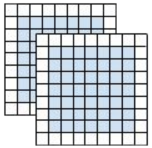
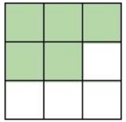
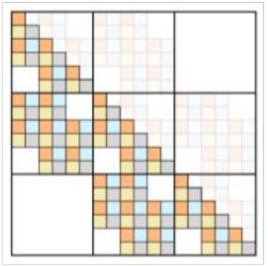
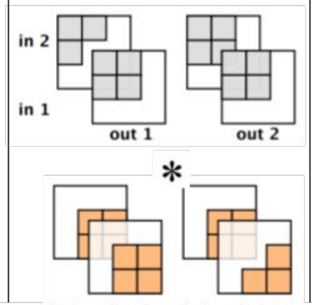
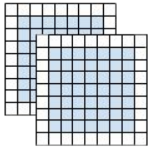
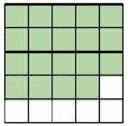
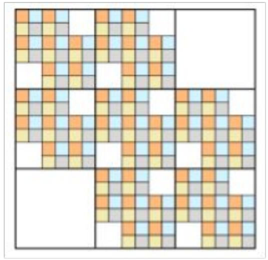


visage shape



hair colour

-modifying the age parameter

	Filters	Padding	Receptive Field	Matrix	Observations n=#in,out channels.
CInC (Ours) Convolution					#learnable parameters **$9n^2$ - $n(n-1)/2$** #convs = **1** Invertibility is guaranteed in training since diagonal entries of matrix are 1s.
Autoregressive Convolutions					#learnable parameters **$5n^2$** #convs = **1** Number of learnable parameters are reduced by almost 50% resulting in lesser expressive power.
Germain et al., Made: Masked autoencoder for distribution estimation.ICML 2015. Kingma et al., Improved variational inference with inverse autoregressive flow, NIPS 2016.					
Emerging Convolutions					#learnable parameters **$10n^2$** #convs = **2** Having more convolutions will increase runtime during generation as well as latent vector computation passes.
Hoogeboom et al. Emerging Convolutions for Generative Normalizing Flows. ICML, 2019.					