

# See-through inverse halftoning and generative adversarial testing of image formation model

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*Workshop on Machine Learning – Assisted Image Formation, Nice July 10-12, 2019*

# Halftoning



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# Inverse halftoning



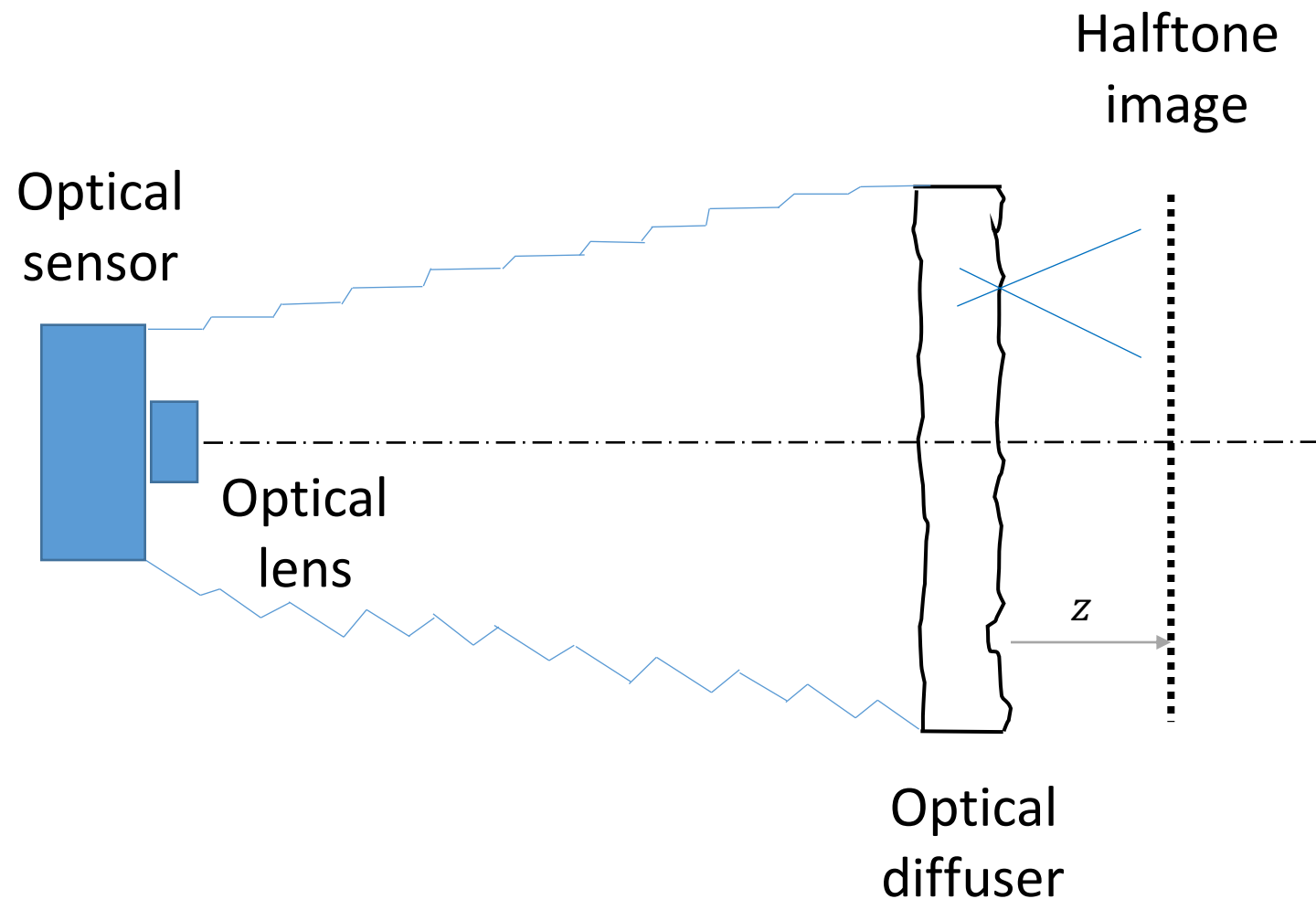
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# Optical inverse halftoning



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# Optical set-up



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$z = 0$

*Some dots are still visible!*

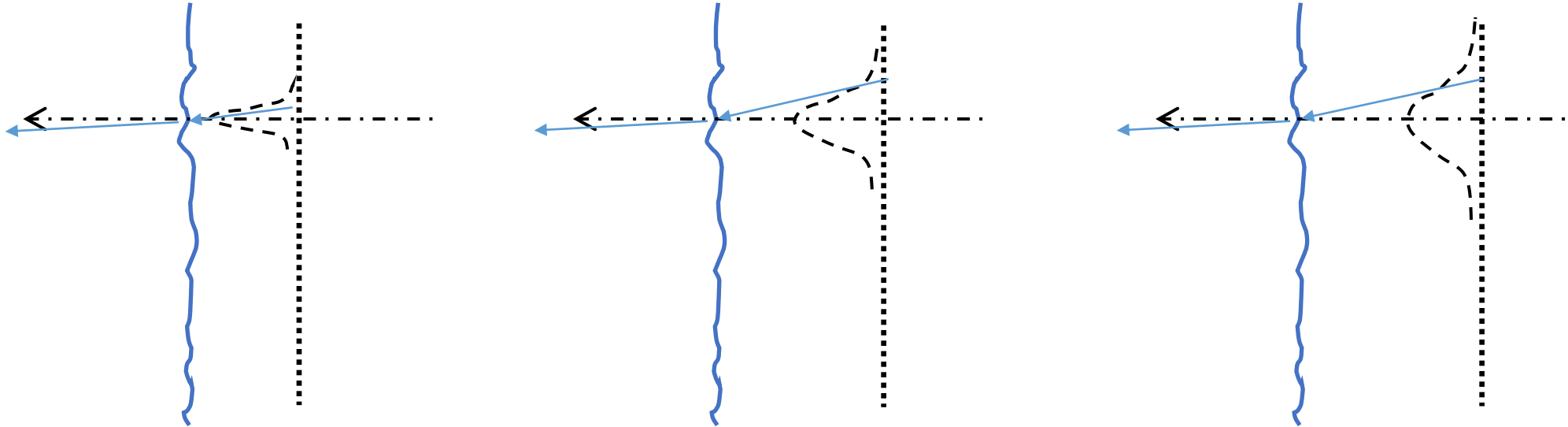
*The dots are no more visible!*

*The image appears blurred!* **z**

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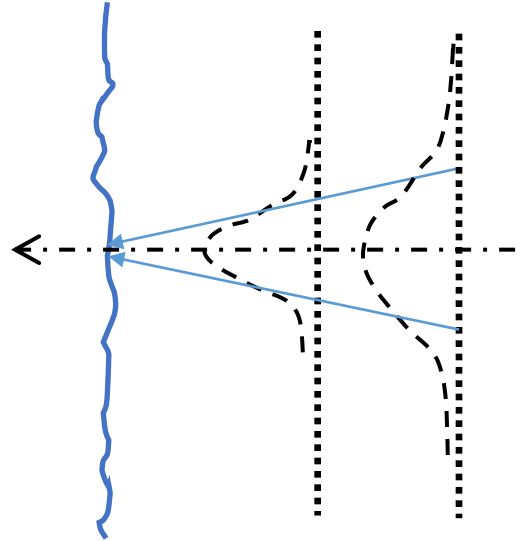


# Image model of a single interface



$$\varphi[I](x) = N(x, \omega) \cdot (h * I)(x)$$

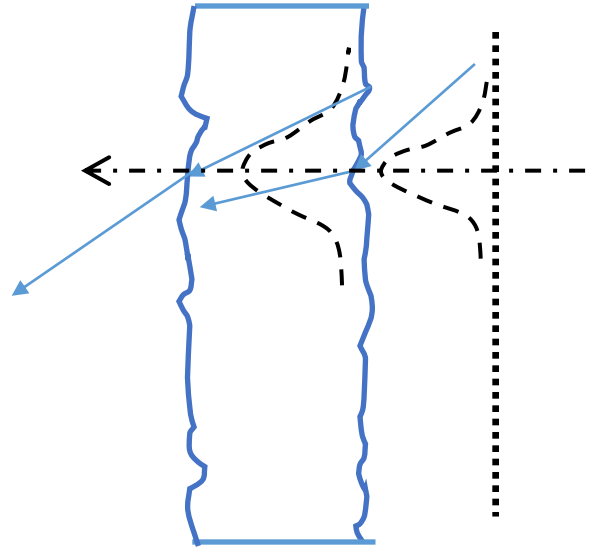
# Image model of a single interface



$$\varphi[I](x) = N(\mathbf{x}, \omega) \cdot (h * I)(x)$$

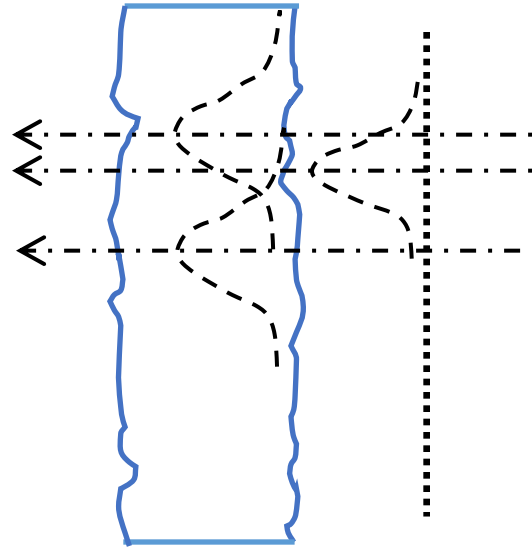


# No volumic diffusion



$$\Phi[I] = \varphi_{out}[\varphi_{in}[I]] \approx \varphi_{in}[I]$$

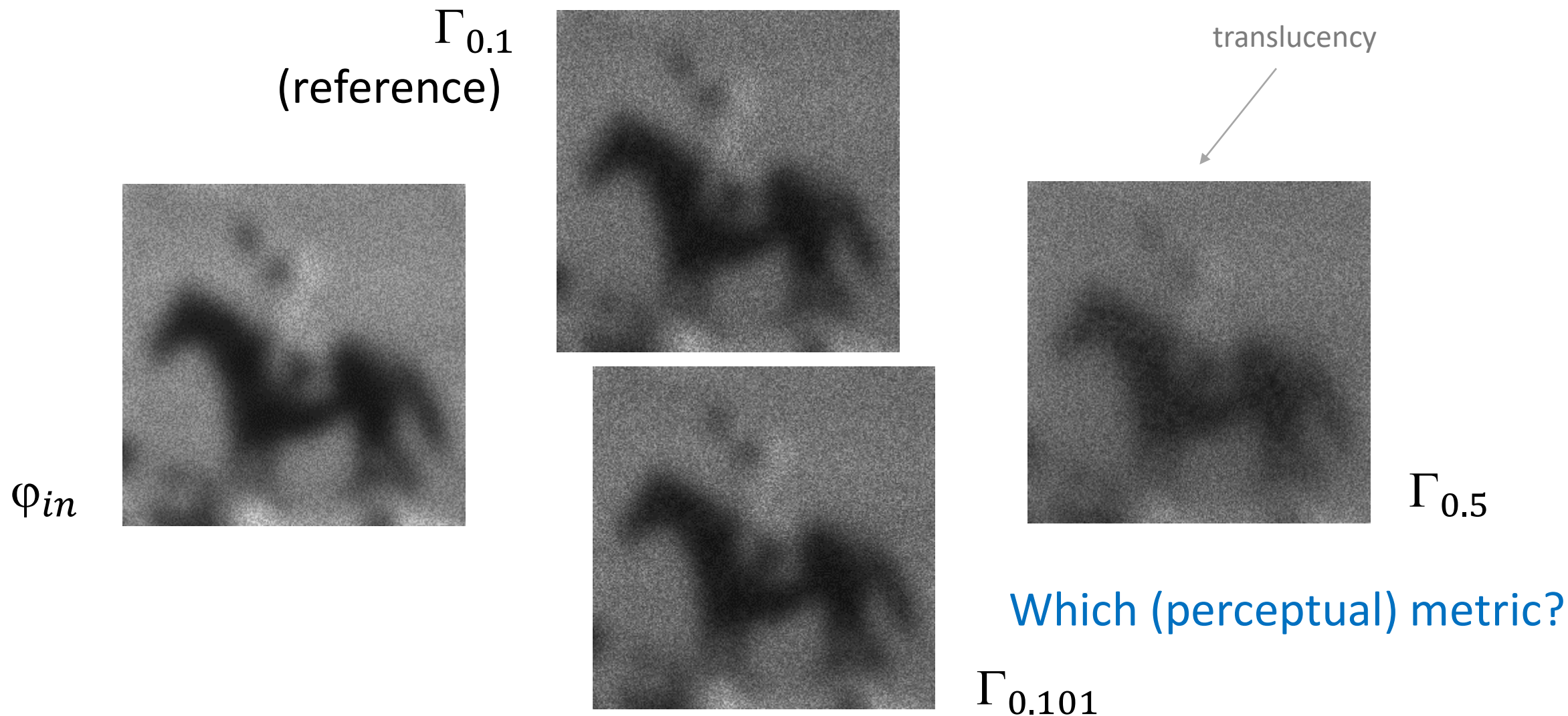
# With volumic diffusion



$$\Gamma_p[I] = N \cdot \left( (g * B_p) \cdot \varphi_{out}[\varphi_{in}[I]] + \left( 1 - (g * B_p) \right) \cdot \varphi_{in}[I] \right)$$

where  $B_p \sim Ber(p)$

# A set of physical image models \ classes



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Fig. 2. Comparison of "Boat" images with different types of distortions, all with MSE = 210. (a) Original image (8bits/pixel; cropped from 512×512 to 256×256 for visibility); (b) Contrast stretched image, MSSIM = 0.9168; (c) Mean-shifted image, MSSIM = 0.9900; (d) JPEG compressed image, MSSIM = 0.6949; (e) Blurred image, MSSIM = 0.7052; (f) Salt-pepper impulsive noise contaminated image, MSSIM = 0.7748.

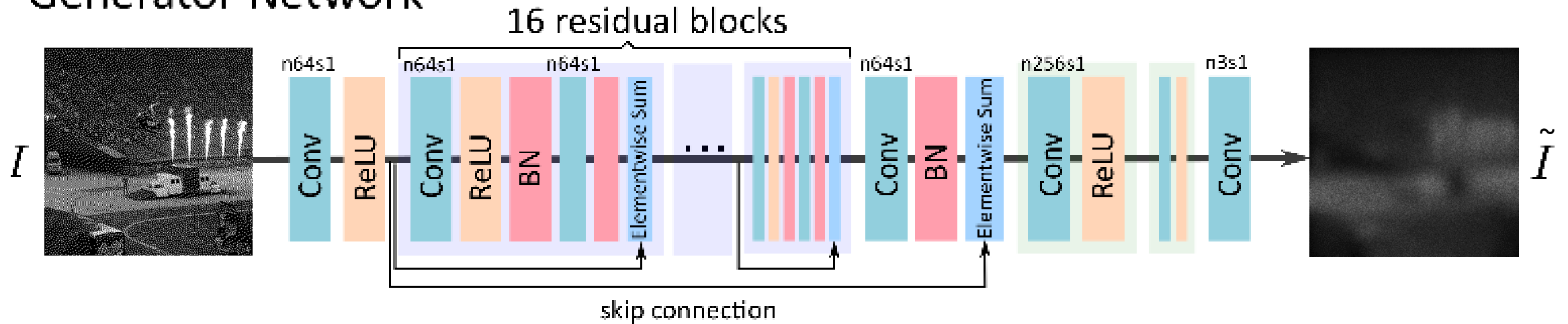
$$SSIM(x, y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1} \cdot \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2} \cdot \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3}$$

Let us consider the question of model assessment  
jointly with modeling

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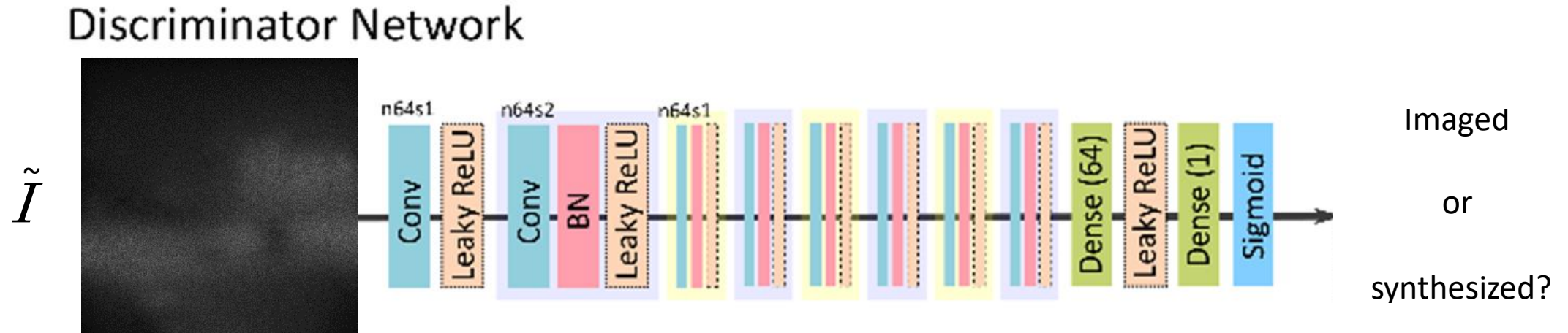
# A data-driven model, $G[I]$

## Generator Network



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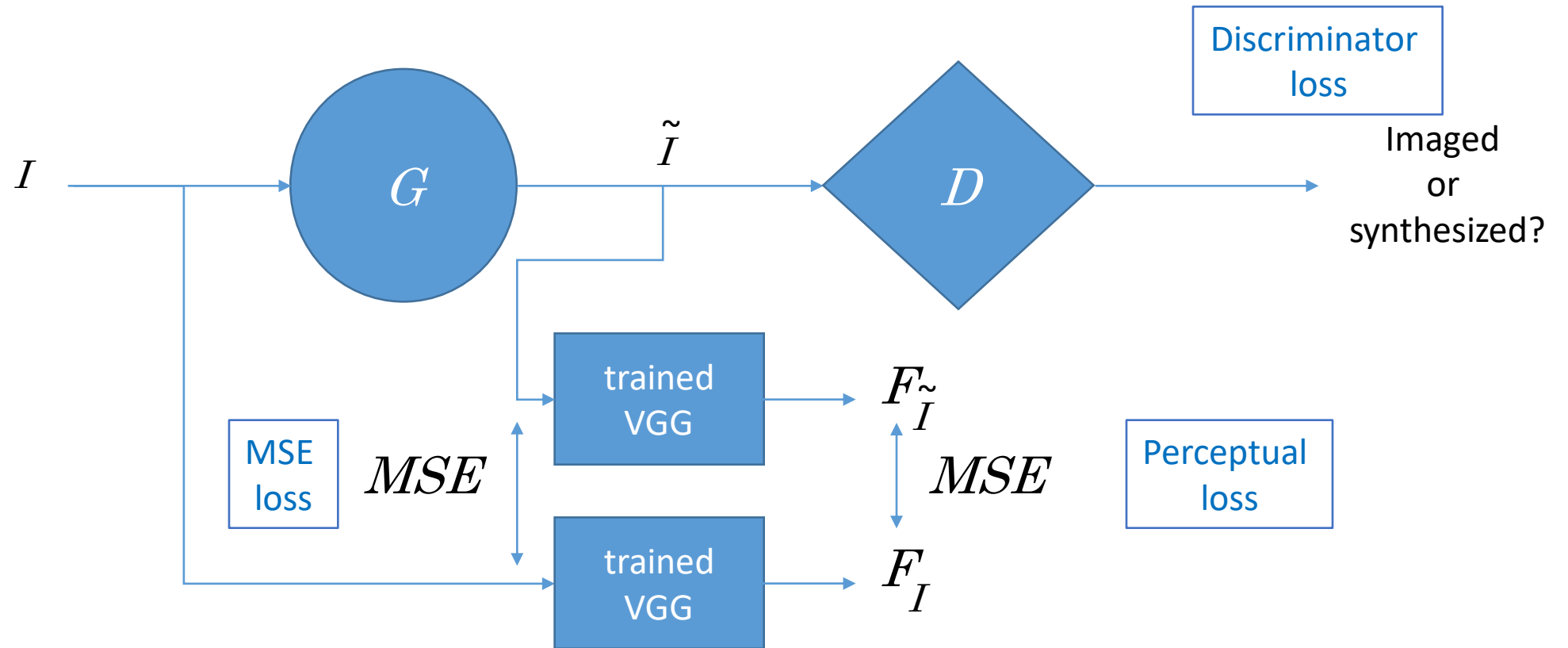
# ... and an expert network $D$



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# .. in a compet for « machine training »



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$$loss_{perceptual} = loss_{content} + loss_{adversarial}$$

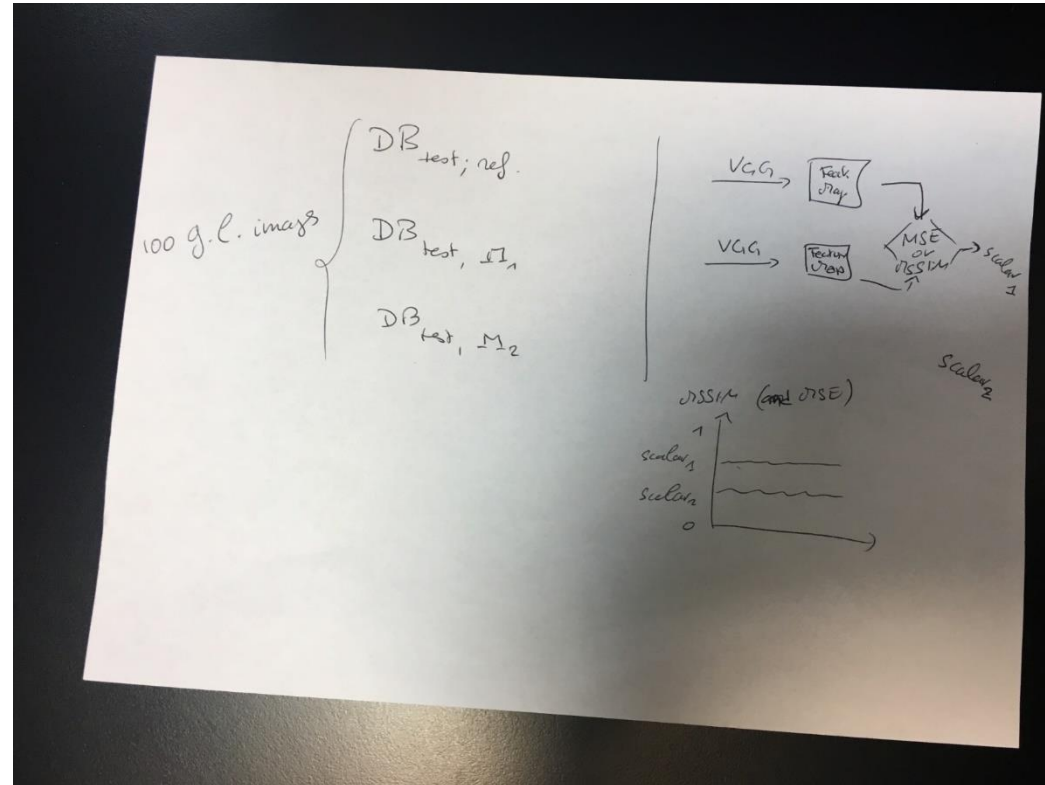
$$l_{MSE} = \frac{1}{r^2WH} \sum_{x=1}^{rW} \sum_{y=1}^{rH} (\tilde{I}_{x,y} - G_{\theta_G}(I^{in})_{x,y})^2$$

$$l_{VGG/i,j}^{SR} = \frac{1}{W_{i,j}H_{i,j}} \sum_{x=1}^{W_{i,j}} \sum_{y=1}^{H_{i,j}} (\phi_{i,j}(I^{out})_{x,y} - \phi_{i,j}(G_{\theta_G}(I^{in})_{x,y}))^2$$

$$l_{Gen} = \sum_{n=1}^N -\log D_{\theta_D}(G_{\theta_G}(I^{in}))$$

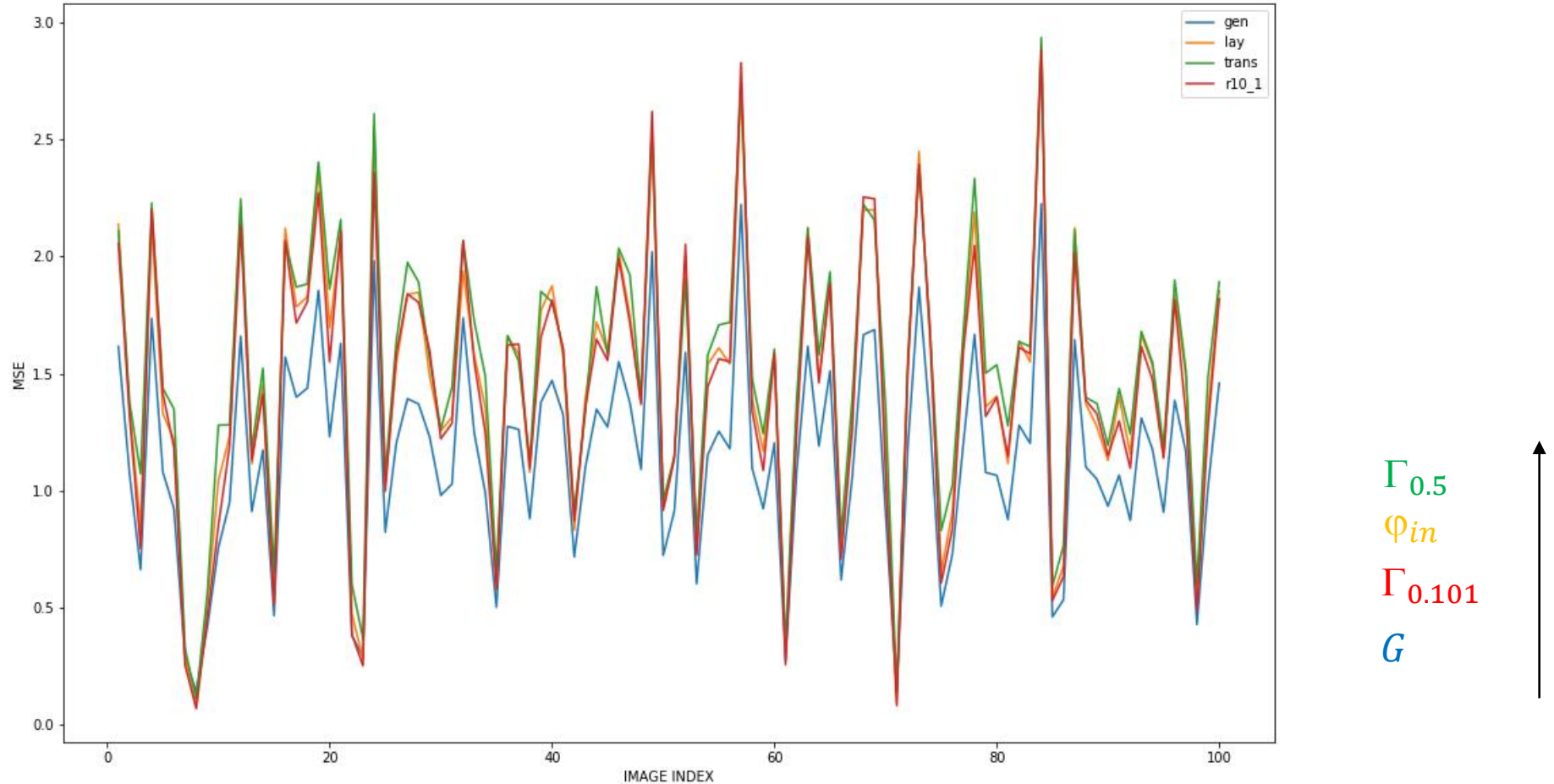
- 1000 images extracted from VOC2012 database  
resized to 256x256 and error diffusion halftoned
- 650 images for training, 100 for validation and 250 for testing
- GAN architecture derived from SRGAN

# Roadmap of the small experiment (simulation)



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# Results



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# Pre-conclusion

- A physical model and a generative adversarial methodology for testing it have been suggested
- The obtained hierarchy between the model and its approximations looks good
- The closest instance remains beyond the generative image model650 images: a Panda effect?
- Other metrics as EMD could be tested.

*Thank you for your attention!*