



SAR2SAR: A Semi-Supervised Despeckling Algorithm for SAR Images

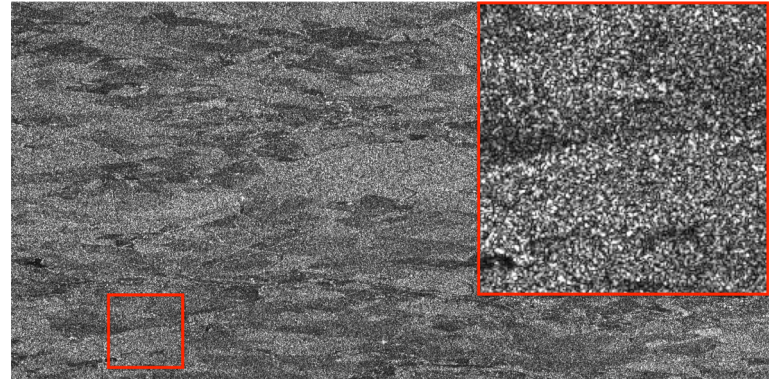
Dalsasso, Emanuele, Loic Denis, and Florence Tupin.
"SAR2SAR: a semi-supervised despeckling algorithm for
SAR images." IEEE Journal of Selected Topics in Applied
Earth Observations and Remote Sensing (2021).



SAR images: application and background information

■ Fields of application:

- Urban monitoring
- Land use mapping
- Biomass estimation
- Damage assessment
- Ice monitoring
- ...



Example of a Sentinel-1 SAR image ©ESA

Speckle model

- Fully developed speckle model proposed by *Goodman et al.* relates the measured intensity w , the underlying reflectivity v , and the speckle u as follows:

$$I = R \times S$$

$$\mathbb{E}[S] = 1$$

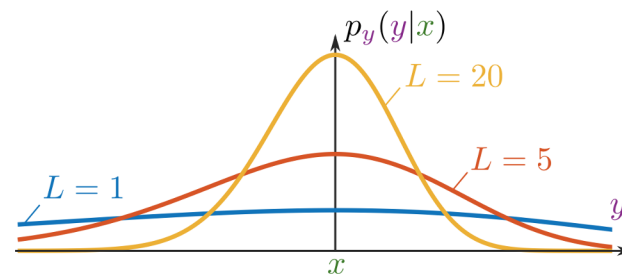
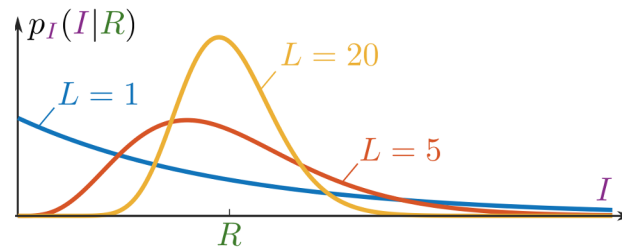
$$\text{Var}[S] = \frac{1}{L}$$

- After a log transform:

$$y = x + s$$

$$\mathbb{E}[s] = \psi(L) - \log(L)$$

$$\text{Var}[S] = \psi(1, L)$$

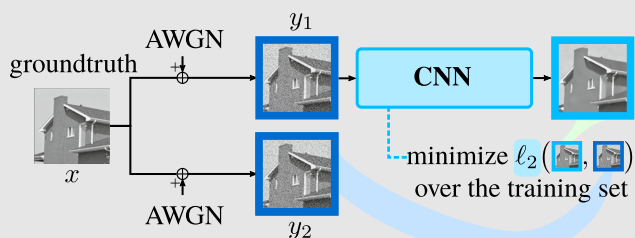


From noise2noise to SAR2SAR: loss formulation

Noise2noise [Lehtinen et al. 2018]

The noise2noise framework: training strategy

- 1 Generate noisy pairs (y_1, y_2)
- 2 Update network from a groundtruth image



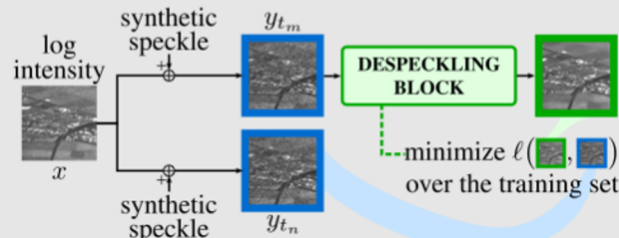
with $y = x + n$ and $y' = x + n'$

$$\operatorname{argmin}_{\theta} \mathbb{E}_{(y, y')} [L(f_{\theta}(y), y')]$$

SAR2SAR

A. Initial training: synthetic speckle realizations

- 1 Generate noisy pairs (t_m, t_n)
- 2 Update network from a groundtruth image

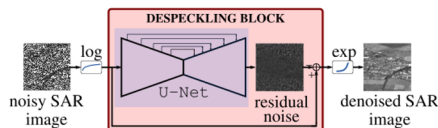


with $y = x + s$ and $y' = x + s'$

$$\operatorname{argmin}_{\theta} \mathbb{E}_{(y, y')} [\ell(f_{\theta}(y), y')] = \operatorname{argmin}_{\theta} \mathbb{E}_{(y, y')} [-\log p(y' | f_{\theta}(y))]$$

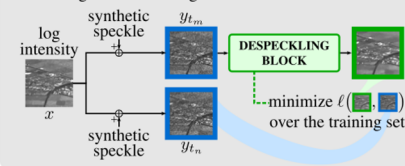
SAR2SAR: learning strategy (C)

Structure of the despeckling algorithm



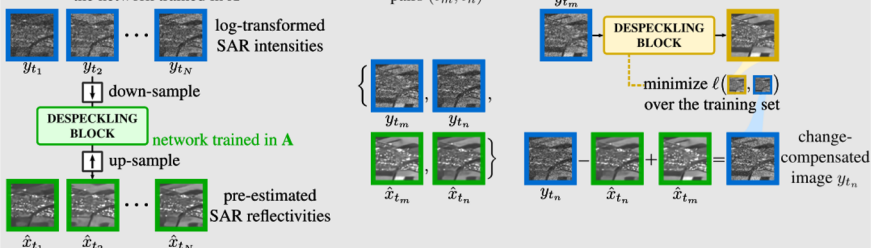
A. Initial training: synthetic speckle realizations

- 1 Generate noisy pairs (t_m, t_n) from a groundtruth image
- 2 Update network



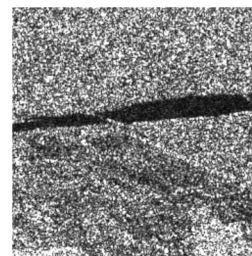
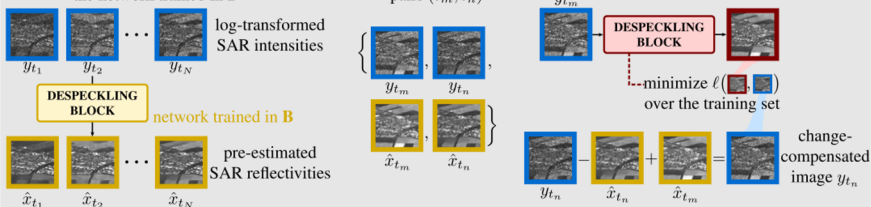
B. Fine tuning on actual SAR images

- 1 Pre-estimate reflectivities with the network trained in A
- 2 Draw random pairs (t_m, t_n)
- 3 Update network

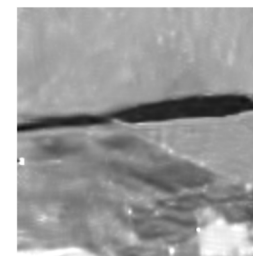


C. Second refinement using improved pre-estimated SAR reflectivities

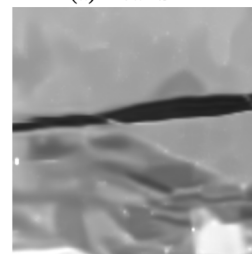
- 1 Pre-estimate reflectivities with the network trained in B
- 2 Draw random pairs (t_m, t_n)
- 3 Update network



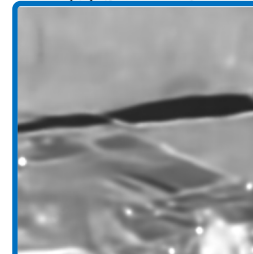
(a) Real SAR



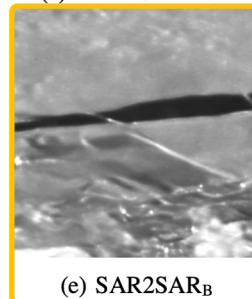
(b) SARBM3D



(c) MuLoG+BM3D



(d) SAR-CNN



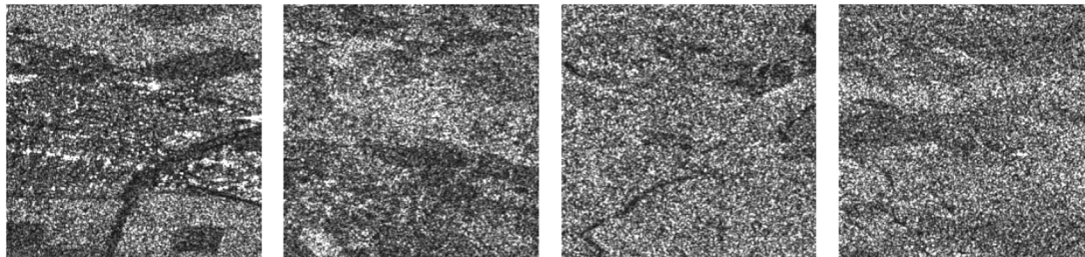
(e) SAR2SAR_B



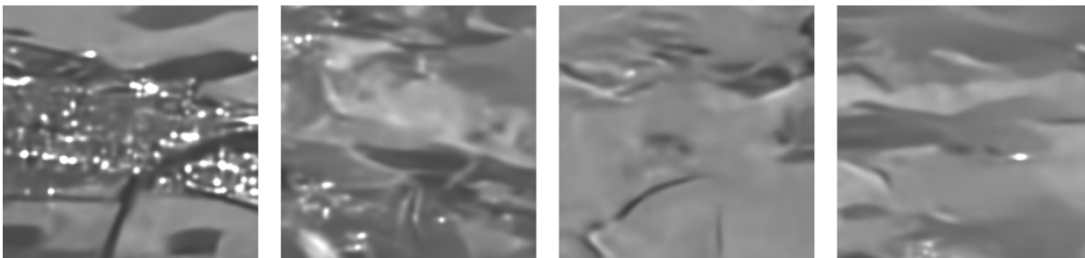
(f) SAR2SAR_C

SAR2SAR

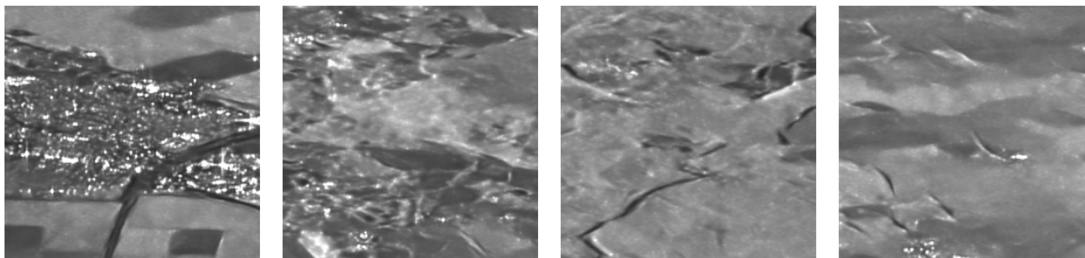
SAR image



SAR-CNN



SAR2SAR





**Thank you for watching
this video**