Combining GANs and AutoEncoders for Efficient Anomaly Detection

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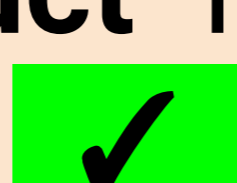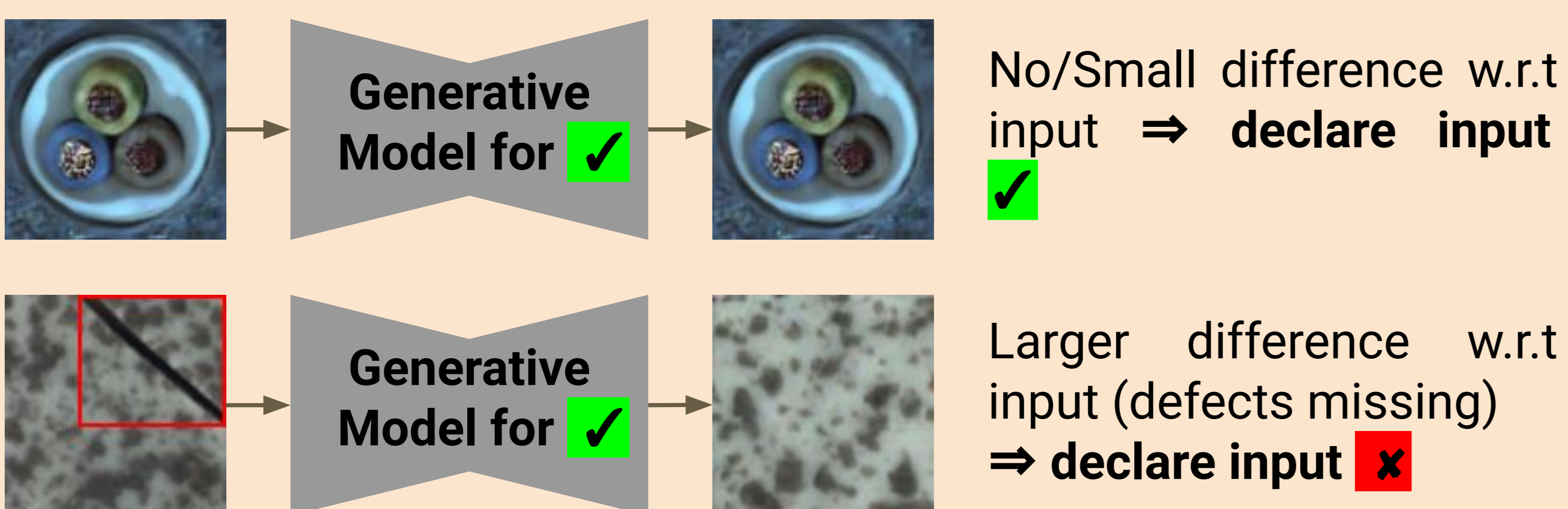✉ fabio.carrara@isti.cnr.it   ⊙ https://github.com/fabiocarrara/cbigan-ad

GitHub
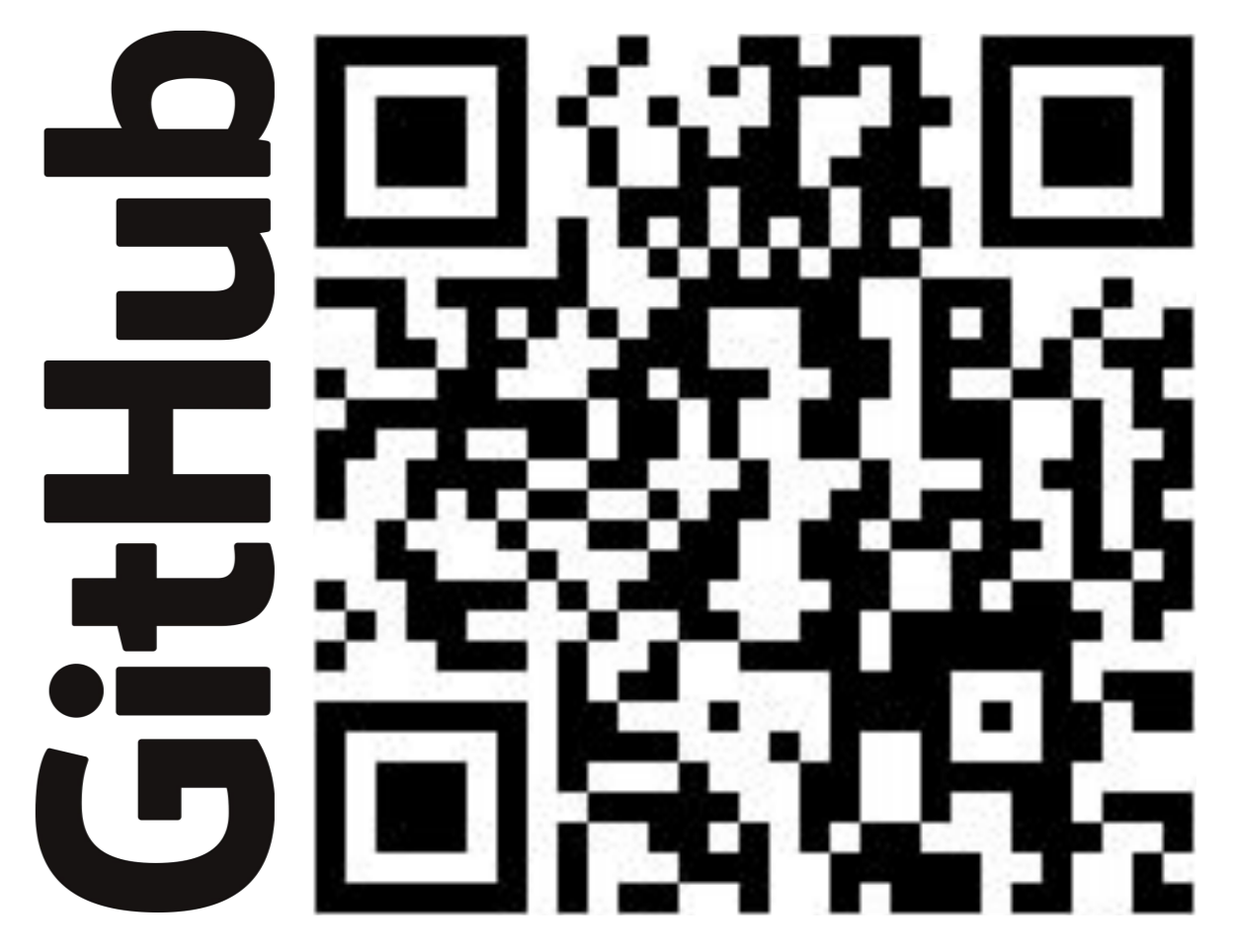
The Problem: Visual Anomaly Detection

GOAL: detect anomalous images (assign either ✔ or ✘ to input image)

HOW: Fit a *generative model* to **reconstruct** non-anomalous inputs (one-class training, only ✔ are commonly available in the training phase)

No/Small difference w.r.t input ⇒ **declare input** ✔

Larger difference w.r.t input (defects missing) ⇒ **declare input** ✘

CBiGAN: Consistency BiGAN Model

We propose a *combined* model named **CBiGAN**

Bidirectional GAN

AutoEncoder

$$\mathcal{L}_{\text{total}} = (1 - \alpha) \cdot \mathcal{L}_{\text{adversarial}} + \alpha \cdot \mathcal{L}_{\text{consistency}}$$

pushes **Gen** and **Enc** to make realistic results, **Discr** to spot fakes

pushes **Gen** and **Enc** to produce outputs consistent with inputs

+ generalizes both BiGANs ($\alpha = 0$) and AEs ($\alpha = 1$), α can be tuned
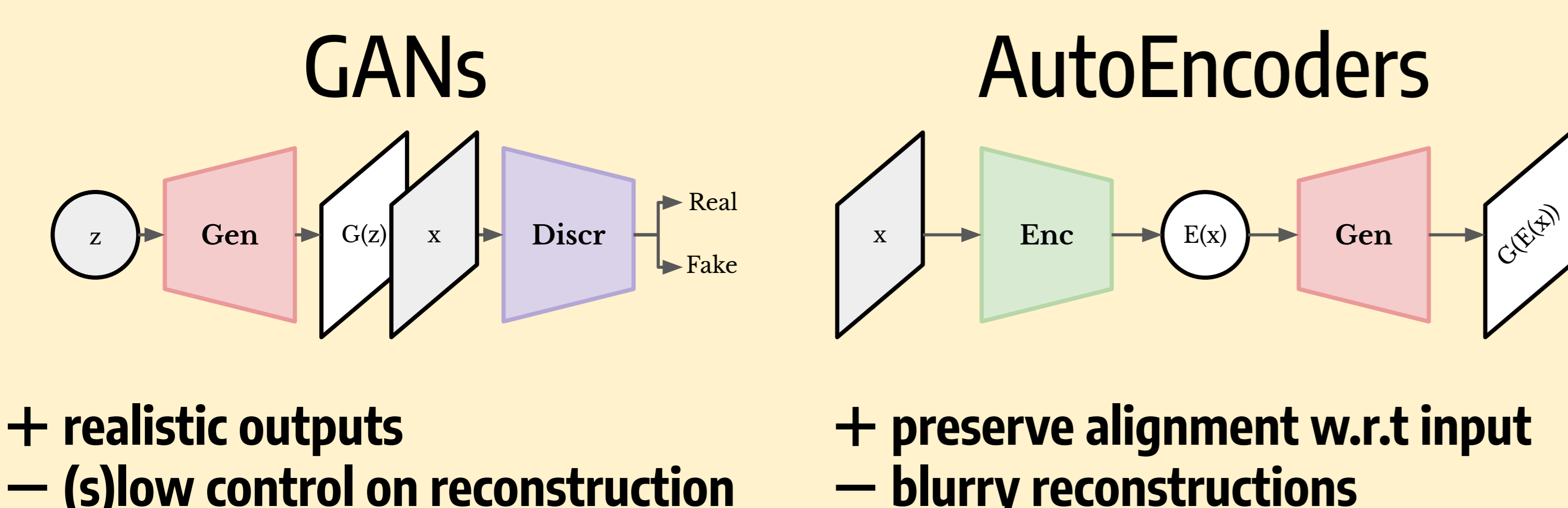+ produces realistic outputs fast that are consistent with inputs

The State of The Art

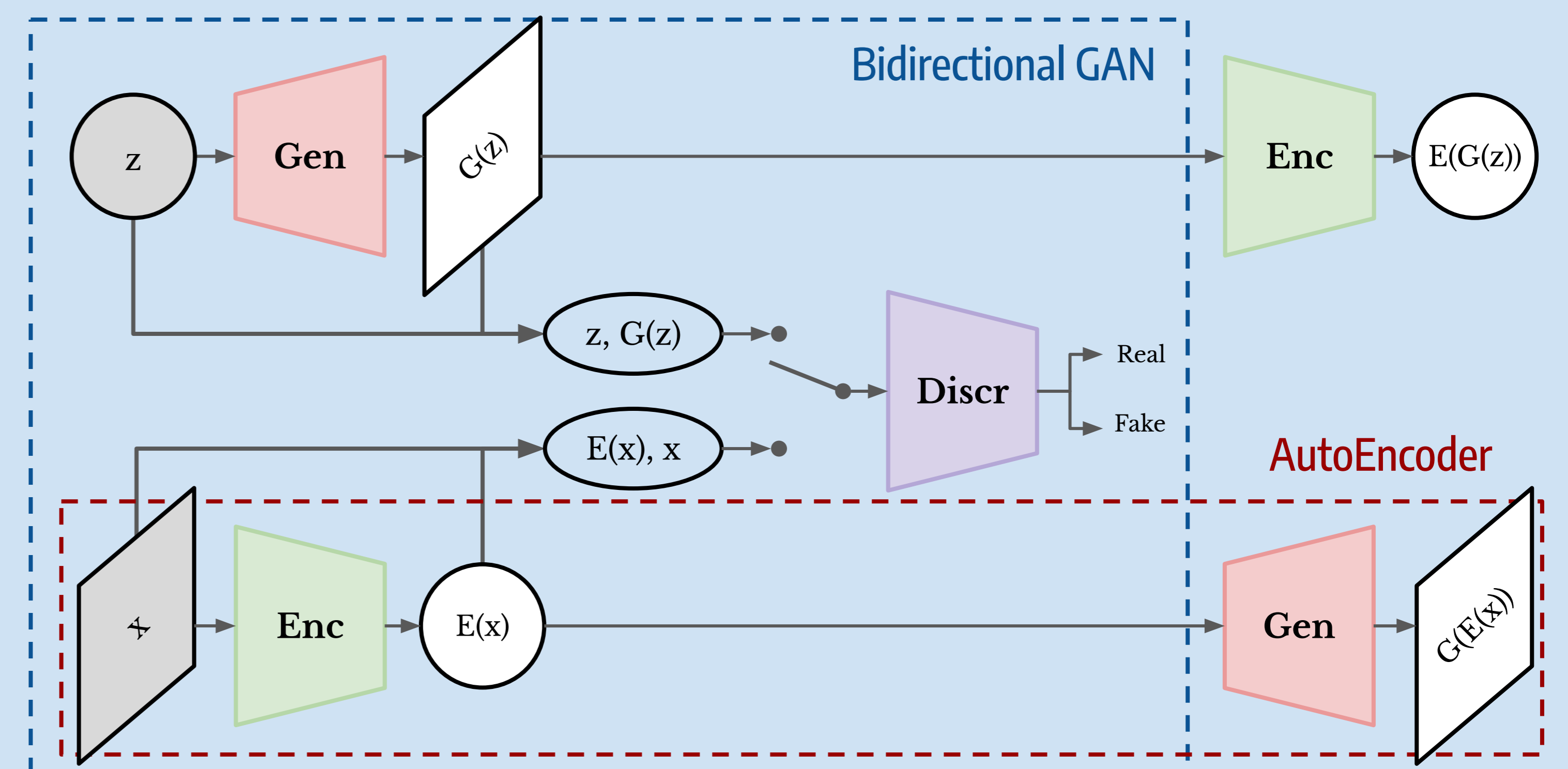Generative models used in reconstruction-based methods often are GANs and AE (vanilla & VAEs)

- *Iterative methods*: reconstructions are optimized via multiple iterations for each input
  - better reconstructions, but very expensive
  - Es: AnoGAN, VAE-grad

- *Single-pass methods*: reconstruction obtained in a single forward pass (often an Encoder-Decoder)
  - more efficient, less precise reconstructions
  - Es: EGBAD (BiGAN), AE L2/SSIM, AVID, LSA, etc.

Among *single-pass* methods, the two commonly approaches adopted are:

GANs

+ realistic outputs
− (s)low control on reconstruction

AutoEncoders

+ preserve alignment w.r.t input
− blurry reconstructions

Evaluation: MVTec-AD Dataset

	Textures	Objects	Overall
Iterative Methods			
AnoGAN	0.54	0.56	0.55
VAE-grad	0.78	**0.76**	**0.77**
Single-pass Methods			
AE$_{L2}$	0.65	0.74	0.71
AVID	0.67	0.75	0.73
LSA	0.69	0.75	0.73
EGBAD (BiGAN)	0.66	0.58	0.61
CBiGAN (ours)	**0.84**	0.73	0.76

	Textures	Objects	Overall
AE$_{L2}$	0.80	**0.74**	0.75
GeoTrans	0.59	0.71	0.67
GANomaly	0.77	0.76	0.76
EGBAD	0.66	0.57	0.60
CBiGAN (ours)	**0.85**	0.73	**0.77**

↑ Area Under the Curve (AUC)

← Balanced Accuracy = (TPR + FPR) / 2 when using the Youden threshold. Best among single-pass methods.

| Query Image | BiGAN (recon.) | BiGAN (diff.) | Ours (recon.) | Ours (diff.) |