Adversarial Anomaly Detector

Use of Generative Adversarial Networks for the detection of tomato diseases

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Content

Context

Tomato production

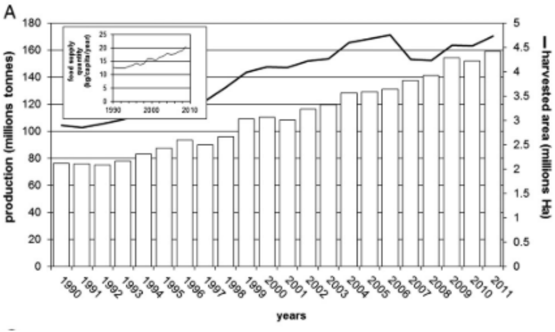


Figure: Tomato production worldwide. Reprinted from Bergougnoux, V. (2014). The history of tomato: From domestication to biopharming. Biotechnology Advances.

Context

Tomato production

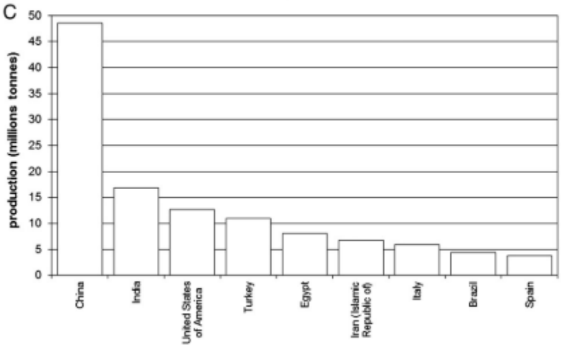


Figure: Tomato production per country. Reprinted from Bergougnoux, V. (2014). The history of tomato: From domestication to biopharming. Biotechnology Advances.

Problem

Detection of disease and pest in tomato crops with the use of non-invasive systems that help mitigating the consequences of climate change on food security.

Objectives

General objective

Evaluation of different algorithms for anomaly detection, in the context of tomato images.

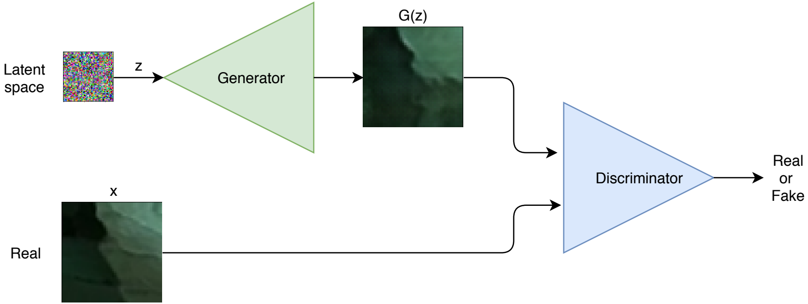
Objetives

Specific objectives

- To design a dataset to train the machine learning models.
- Selection of anomaly detection algorithms.
- To evaluate the selected methods for anomaly detection in tomato images.

Anomaly detection with generative adversarial networks

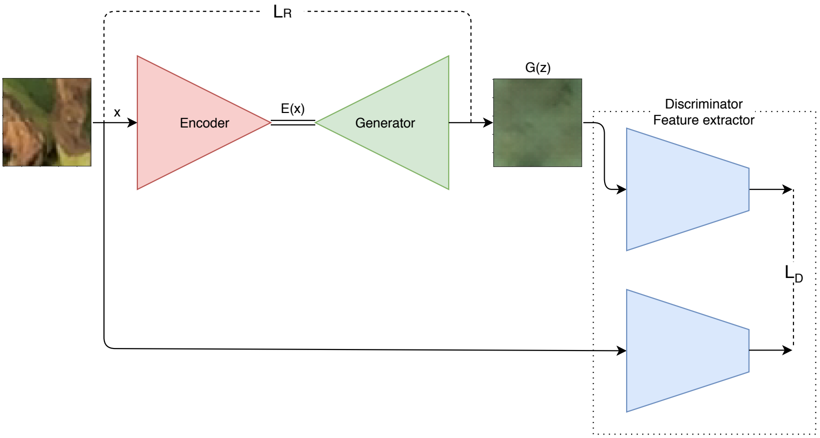
Generative Adversarial Networks architecture



$$\min_G \max_D V(D,G) = \mathbb{E}_{x \sim p_{\text{data}}(x)}[\log D(x)] + \mathbb{E}_{z \sim p_z(z)}[\log(1 - D(G(z)))]$$

Anomaly detection with generative adversarial networks

Adversarial Anomaly Detector architecture



Anomaly detection with generative adversarial networks

Adversarial Anomaly Detector loss function

$$\mathcal{L}\left(\mathbf{E}(x)\right) = (1-\lambda)\cdot\mathcal{L}_R\left(\mathbf{E}(x)\right) + \lambda\cdot\mathcal{L}_D\left(\mathbf{E}(x)\right)$$

where the reconstruction error $\mathcal{L}_R$ and the discriminator error $\mathcal{L}_D$ are defined as follows:

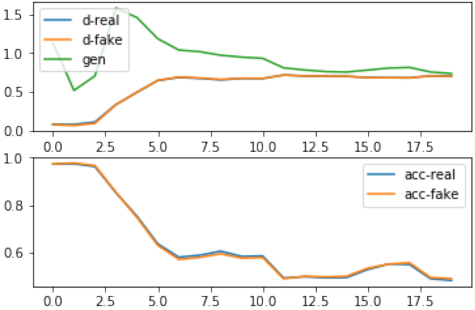
$$\mathcal{L}_R\left(\mathbf{E}(x)\right) = \left\|\mathbf{x} - G\left(\mathbf{E}(x)\right)\right\|$$

$$\mathcal{L}_D\left(\mathbf{E}(x)\right) = \left\|\mathbf{f}(\mathbf{x}) - \mathbf{f}\left(G\left(\mathbf{E}(x)\right)\right)\right\|$$

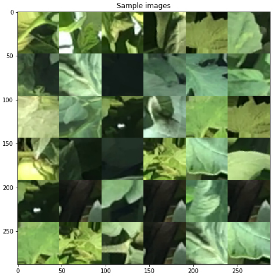
GAN training

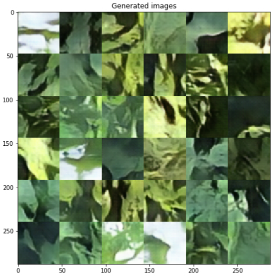
- 191520 images were used for training and 798 for testing.
- Each image is RGB and has a dimension of 50×50.
- The training set is composed with only healty samples of tomato.
- To get a good performance of the model, the training of it took around 20 epochs.

GAN training



GAN training



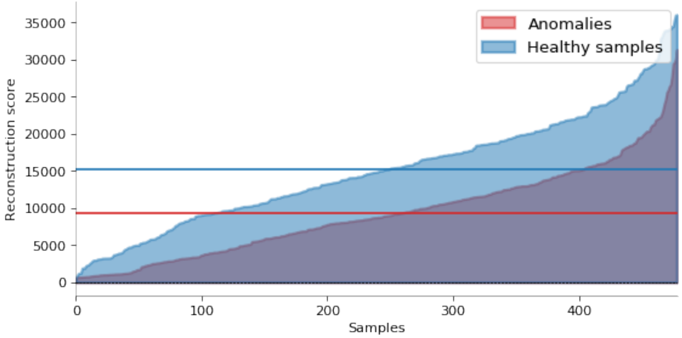


Reconstruction evaluation

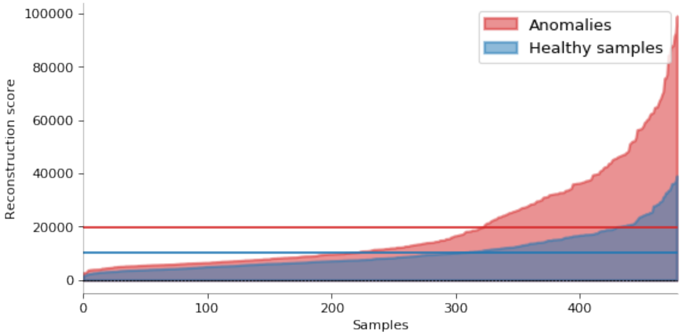
Table: Reconstruction metric evaluation.

Model	Mean (healthy)	STD (healthy)	Mean (anomalies)	STD (anomalies)
sVAE	10410.6	7020.3	19858.8	18464.1
GM-VAE	15162.2	7597.3	9357.3	6071.7
AAD	3839.5	3251.1	8996.1	3308.8

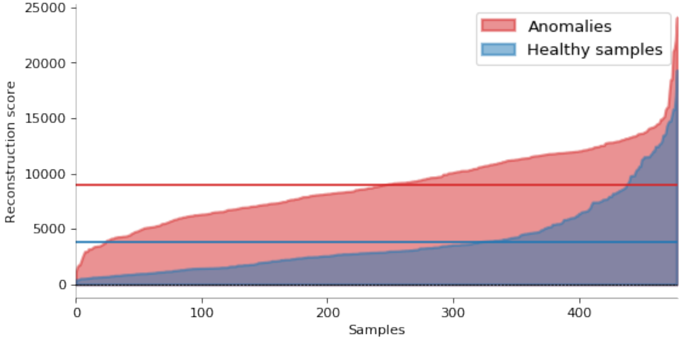
Reconstruction evaluation



Reconstruction evaluation



Reconstruction evaluation



Reconstruction evaluation

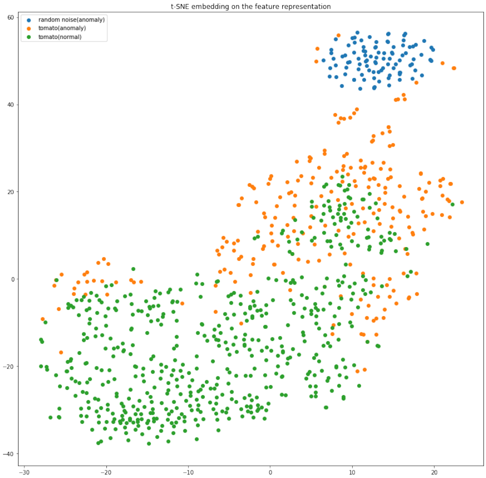
Table: Reconstruction time evaluation.

Model	Reconstruction time (ms)
sVAE	160.8
GM-VAE	1383.1
AnoGAN	6320.6
Adversarial Anomaly Detector	255.3

t-SNE evaluation

Figure: Test image with regular samples

t-SNE evaluation



t-SNE evaluation

Figure: Test image with anomalous samples

t-SNE evaluation

Conclusions

- The experiments performed so far have shown a tendency of the variational autoencoder architectures to blur the reconstructed image
- The GAN-based architectures have more promising results with better reconstruction images
- A modification to the AnoGAN architecture is proposed, allowing to considerably improve the reconstruction time

Future work

- Improve the generator of the GAN.
- Metrics that evaluate the GAN performance need to be explored, along with more metrics for the evaluation of the anomaly detector.
- A segmentation process should be implemented in order to mark possible anomalous regions.

Summary