Improving the Classification of an unbalanced Spheroid Dataset by Augmentation with synthetic Images generated with GANs

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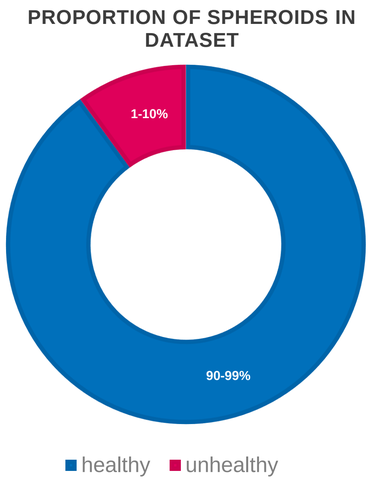
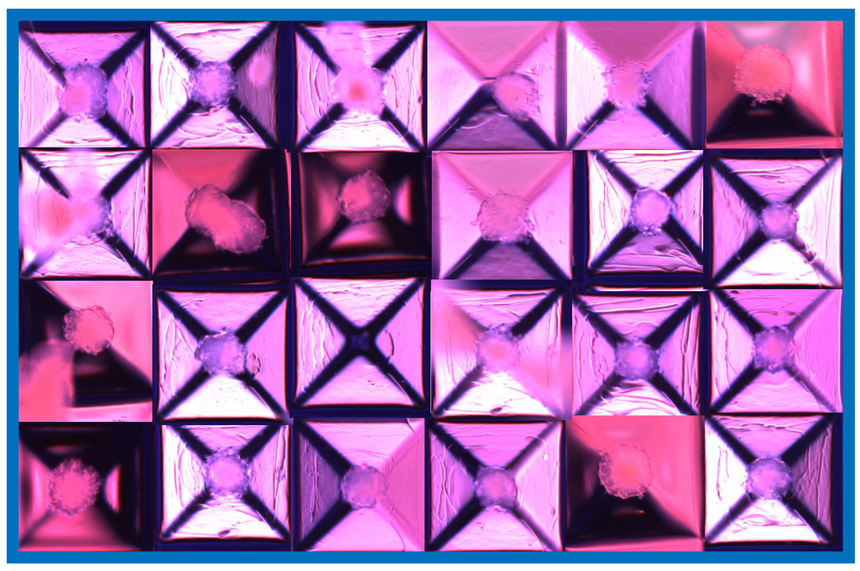
Spheroids have become increasingly relevant as organ and disease models. Those small spherical tissues have a three-dimensional shape promising an efficient and reliable replication of in-vivo cells. A cell line used for hepatotoxicity studies, the HepG2 spheroids lineage typically exhibit a high class imbalance of 1:10 or worse as the rare phenotypes are developing with very low probabilities. For some experiments these spheroids need to be sorted early during the cell culture to remove unhealthy spheroids. Wrongly classified spheroids can pollute entire batches, making it potentially dangerous for subsequent applications. For efficient experiments high-throughput sorting is needed and can be achieved by automation via microscopy and in-silico classification. For complex image classification tasks deep learning is a very powerful technique. However, for training deep learning models successfully all classes need to be represented sufficiently in the training data, which is problematic with unbalanced data sets. Here we studied if the classification accuracy of unbalanced datasets can be improved by augmenting the number of samples of the rarer class by synthetic image generation with three adversarial generative networks (GANs) architectures. Our results show a significant increase in F1 score of the classification models when augmenting with styleGAN2-ADA-generated images compared to the baselines with and without traditional augmentation methods. This novel application of GANs can improve the classification of similar unbalanced datasets helping to understand mechanisms of rare phenotypes and associated diseases.

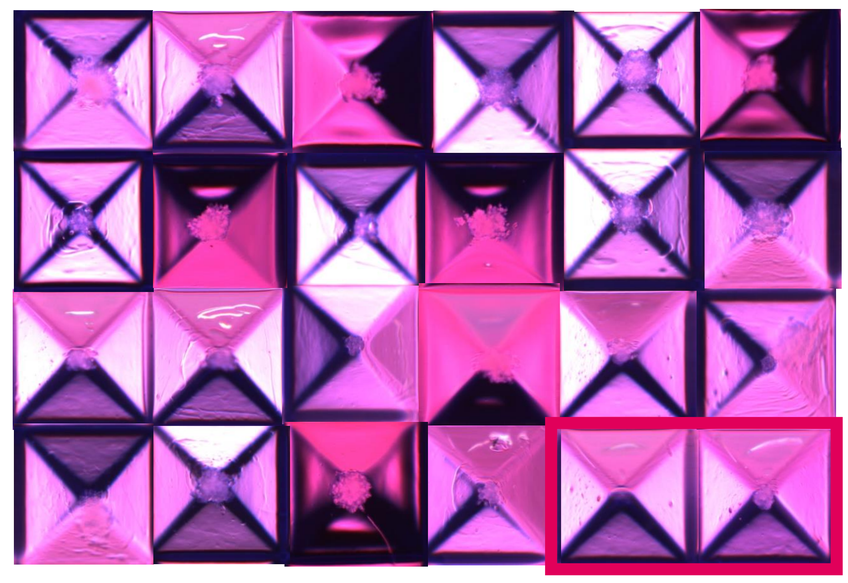
Automated Spheroid Classification

- **Example of the real unbalanced dataset of 10’000 spheroids images from OrganTrans dataset.**



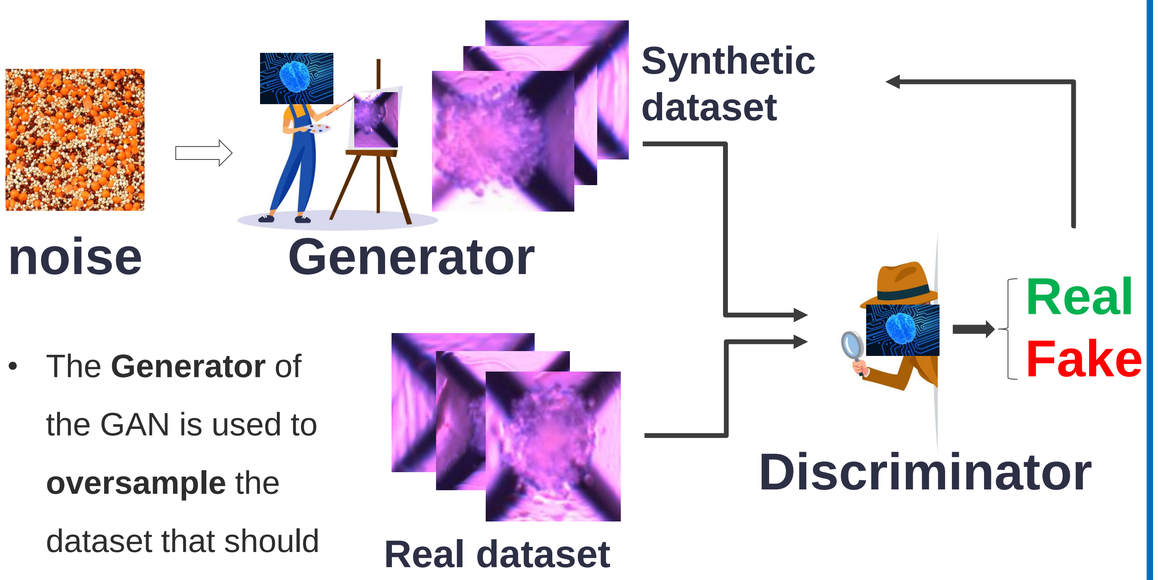


- **Healthy spheroids:** **>90%**



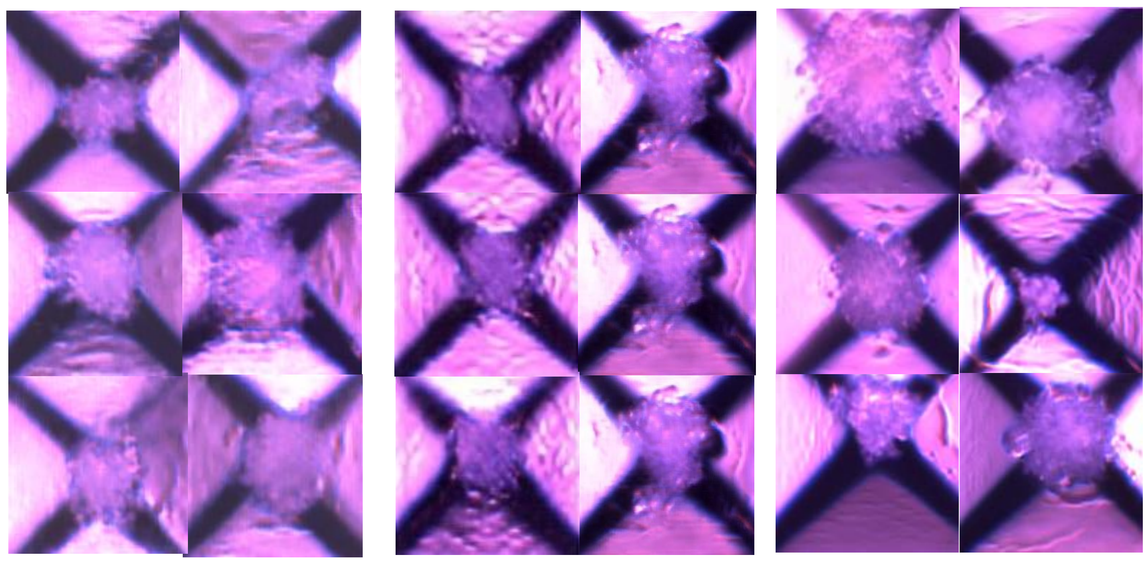
- **Unhealthy spheroids:** **<10%**

Generative Adversarial Networks



- The **Generator** of the GAN is used to **oversample** the dataset that should be classified

Synthetic Generated Images



- **DCGAN**
- **BigGAN**
- **StyleGAN2-ADA**

Generative Data Augmentation Performance

- The **synthetic GANs generated images** resemble the real dataset distribution. Experts **couldn't distinguish** between them.
- The **classification accuracy** significantly **increased** with the input of **synthetic** unhealthy spheroids. An **increase of F1 score <5%** for 10% unhealthy spheroids and **<15%** for 1% of unhealthy spheroids, for the generative models trained with 200, 2’000 or 15’000 images of unhealthy spheroids.
- There are a lot of **limitations** to include **deep fakes** in the **medical field**, but they could be a potential **solution** to small and unbalance data problems.