**Title:** Utilization of Cycle-Consistent Adversarial Networks for Transformation and Elimination of Port-Wine Birthmarks in Photographic Imagery

**Background:**

The domain of Generative Adversarial Networks (GANs) has demonstrated significant proficiency in the creation of novel datasets. Of particular interest is the CycleGAN framework, which is adept at domain translation (e.g., transmuting ordinary photographs into artworks reminiscent of Monet). Employing a four neural networks paired with cyclical loss functions, CycleGAN acquires the ability to translate between two distinct distributions. In doing so, it garners insights into the intrinsic characteristics of each distribution (e.g., discerning the quintessence of Monet's style). Given these capabilities, CycleGAN seem well-suited for the bidirectional transformation between images of healthy facial structures and those exhibiting Port-Wine Birthmarks (PWB), as well as for deducing the defining features of PWB, since it needs to learn those for a high quality translation. Moreover, we envision the use of this model to raise awareness about PWB and, eventually, to use a similar model to forecast the potential aesthetic enhancement in PWB appearance.

**Study Design and methods:**

Our investigation harvested a dataset comprising images of 200 Caucasian individuals with PWB from various internet sources, representing a broad age spectrum, primarily children and middle-aged adults. Complementary to this, we incorporated over 7,200 facial images from an open-source repository. We initialized a CycleGAN architecture, training it on a free-to-use Kaggle GPU. The model included four intrinsic neural networks—two generators for image synthesis and two discriminators for classification of PWB and healthy facial images. Resource limitations necessitated a parameter cap (8 million for generators, 2 million for discriminators) and confined image resolution to 256x256 pixels. To enhance training efficiency and model generalization, we adopted data augmentation strategies, focusing on differentiable augmentation that preserves the learned distribution integrity by enabling loss backpropagation.

**Results:**

Subsequent to extensive training iterations and systematic refinements, the CycleGAN achieved convergence, effectively learning to obscure the PWB in images. While the network also acquired the capability to generate images with PWB, the fidelity of these synthetic images remains suboptimal, occasionally failing to meet the recognition criteria of a specialist.

**Conclusion:**

The study conducted has shown the capability of an AI to translate between facial images with Port-Wine Birthmarks to their unmarked counterparts. Although the use of limited computational resources has introduced constraints, leading to translations that are yet to reach an optimal state, the findings affirm the foundational promise of CycleGANs in medical image processing. We envisage the CycleGAN developed in this study as a tool for enhancing public understanding of Port-Wine Birthmarks (PWB), by providing visual simulations of PWB on individuals' faces. Additionally, we hope to expand the utility of CycleGAN to function as a predictive model that can demonstrate potential outcomes for patients considering treatment (eg. transforming pre-treatment photographs to depict the anticipated results after undergoing multiple laser therapy sessions). The primary constraint in realizing the initial objective fully stemmed from the limitations of computational resources, whereas for the latter proposed application, the current main limitation is the amount of data.