The phenomenon of shadows in images is a long-standing challenging, complex, and unassuming obstacle for computer vision tasks, including object detection and depth perception. Common computer vision algorithms are susceptible to the noise generated by shadows in ways that are unintuitive to the human eye, resulting in inaccuracies. To address the omnipresent issue of shadows, researchers separate the problem into two tasks: shadow detection and shadow removal. Then, they seek to create an algorithm that takes in an original, shadowed image as an input and outputs a generated shadow-free, high-quality version of the image.

Research about object detection

Talk about manual stuff

Talk about deep learning

Talk about speeding up deep learning algorithms

Additionally, the approaches to state-of-the-art shadow detection and removal fall into the categories of “Classical” computer vision techniques and Deep Learning algorithms. “Classical” computer vision techniques rigorously process and define an image using mathematical models, then attempt to “undo” the shadow with an emphasis on preserving realism.

One “Classical” shadow detection approach involves approximating shadows using intensity surfaces. Shadows are produced when an object obscures a light source, producing a nonuniform shadow that is separated into the umbra, penumbra regions, which vary in illumination intensity. The presence of shadows in images typically creates a region of reduced illumination intensity, which can be represented by a surface. Intensity surfaces allow the shadow removal algorithm to recognize global features, preserving original image texture and eliminating unwanted image artifacts. However, “Classical” approaches tend to require manual input from users identifying shadow boundaries to form accurate shadow masks, which is unideal.

Alternatively, Deep Learning approaches to shadow detection and shadow removal render manual plotting of anchor points unnecessary and are based on Generative Adversarial Networks (GAN). One approach trains both the shadow detection and shadow removal models based on GAN simultaneously as both tasks are intimately related. The pixel-wise product of the generated image and real image from the dataset from the shadow detection model is fed into the shadow removal model, which produces shadow-free images. Similar to many Deep Learning models, SRODNet suffers from data scarcity and a lack of generalizability to other datasets. To combat this issue, a recent study used an image rendering engine (Unity Game Engine) to produce synthetic tripled data to feed into a GAN. To account for domain bias, real world data was converted into a synthetic style using style transfer and fed into the shadow detection algorithm. The shadow detection algorithm then produced a pseudo-perfect shadow map, which became an input, along with the original image, of the shadow removal algorithm. The output of the shadow removal model would undergo domain adaptation, resulting in a realistic, shadow-free image. Diverging from SRODNet, the shadow detection and shadow removal models were trained separately in recognition of the potential issue of domain bias. This method proved that complex, synthetic edge cases could be generated to train a GAN, addressing the problem of data scarcity.

While both Classical CV and Deep Learning algorithms produce accurate, realistic, shadow-free images, a common pitfall and a gap in the literature is efficiency. The aforementioned classical algorithm takes minutes to process a singular 500 x 500 pixel image, while the deep learning models are trained using state-of-the-art, expensive hardware. One paper discusses the application of Graphical Processing Units (GPU) to accelerate the capabilities of “classical” approaches to shadow detection and shadow removal through separating the algorithm into distinct, independent tasks and processing all kernels in parallel. While the algorithm achieved a 21.67x speedup for shadow removal on images with specific conditions, the paper failed to generalize the algorithm for all cases of shadow removal and detection.