CASE STUDY: Responsible AI

Portrait Light

The Product Feature

Professional portrait photographers often use off-camera illumination to achieve favorable lighting conditions for people with a wide spectrum of skin tones. Inspired by this approach, the Portrait Light feature available in both the Pixel's Camera and Google Photos applications uses multiple machine learning components in a system to instantly add realistic, flattering, synthetic lighting to portraits. Using computational methods to achieve this effect, however,

raised several responsible innovation challenges, including potentially reinforcing unfair bias (AI Principle #2) despite the intention to build a feature that works for all users.

Each of the core machine learning components had its unique challenges. In the real world, light falls on a person's face and interacts with it to create highlights and shadows. To add synthetic lighting to a portrait in a realistic manner, *Portrait Light* needed to first estimate the facial shapes and features of people with diverse skin tones, and use technology to then estimate how that person's face would appear when lit with an additional light source. Furthermore, to add the synthetic illumination from a direction that complements real-world scene lighting, *Portrait Light* needed to reliably estimate the scene illumination from the input portraits, while performing equitably for different individuals. However, lighting estimation algorithms have traditionally struggled to discern whether a photo is taken in dimmer lighting, or if the subject of the photo has a darker skin tone, posing a particularly difficult challenge. For each of the machine learning based components, inclusive training and evaluation data were necessary to achieve equitable performance.

The Approach

Most ML-based approaches require a large volume of image data, in this case, the team required *millions* of pairs of portraits of people both with and without added portrait lighting, and with known initial illumination conditions. Photographing such a dataset in real life would have been extremely time consuming, requiring precise lighting measurement and near-perfect registration of portraits captured across different lighting conditions. Furthermore, any such dataset would need to proportionately represent the diversity of the world.

The research team tackling this problem generated a new, large and diverse training dataset using synthetic, or computer-generated, lighting environments. They worked with 70 people who represent different sub-groups of users. The researchers photographed these individuals using Google's Light Stage, a computational illumination system that captures portraits from a wide variety of camera angles and lighting conditions. Not only did the research team select subjects with a broad range of skin tones, but they also selected subjects with different genders, face shapes, face proportions, and hairstyles. To further avoid unfair bias, the researchers asked each person to perform a variety of facial expressions during the image capture. After capturing the original photographs, the researchers then combined the captured images, generating synthetic portraits of the individuals as they would appear in many different lighting conditions (using a known research method described in this historical paper), both with and without the added portrait lighting.

Using these approaches, with only 70 subjects, the team was able to generate a training dataset containing millions of photos of different people appearing in a diversity of lighting environments, useful for training the face estimation, portrait relighting, and illumination estimation ML components of the Portrait Light feature.

The Outcome

The range of human faces and lighting conditions is vast and will always continue to grow. The team's approach to training the ML components promotes consistency in how they perform computational lighting estimation and portrait relighting for a wide range of people, so that the *Portrait Light* feature overall can create well-lit photographic portraits for users with a diversity of backgrounds. In alignment with AI Principle # 6, in which we state we will responsibly share AI knowledge by publishing educational materials, best practices, and research that enable more people to develop useful AI applications, the team published this paper.

About Google's AI Principles

In 2018, Google published our AI Principles to help guide ethical development and use of the technology. Our objectives: 1. Be socially beneficial. 2. Avoid creating or reinforcing unfair bias. 3. Be built and tested for safety. 4. Be accountable to people. 5. Incorporate privacy design principles. 6. Uphold high standards of scientific excellence. 7.Be made available for use in accord with these principles. In addition to the above objectives, we will not design or deploy AI in the following application areas: 1. Technologies that cause or are likely to cause overall harm. Where there is a material risk of harm, we will proceed only where we believe that the benefits substantially outweigh the risks, and will incorporate appropriate safety constraints. 2. Weapons or other technologies whose principal purpose or implementation is to cause or directly facilitate injury to people. 3. Technologies that gather or use information for surveillance violating internationally accepted norms. 4. Technologies whose purpose contravenes widely accepted principles of international law and human rights. As our experience in this space deepens, this list may evolve.