Detection of Spatial Properties from Images

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Goal:
The goal of this project is to determine the ambient properties (color and magnitude of light, fog, etc.) of a scene based on an image, or images, of that scene. (This is distinct from existing work in lighting detection, which focuses only on lighting but which considers this lighting's direction, occlusion effects, and other very local properties.) Potentially, properties which are not intrinsically part of the scene but which will likely apply to all of its objects (such as snow) may be considered as well. Quantitative data can be given for lighting information, and more qualitative, categorical results can be given for properties such as snow and fog which cannot be as reliably judged from small sets of images.

Use cases:
This project can be used to automatically categorize images based on factors likely to have produced their ambient properties. For instance, images can be automatically categorized as night or day based on light color and amplitude, and as summer, winter, etc. based on fog or snow. It may be possible to determine these properties even when a human could not, such as determining whether it is day or night in an image where the sky is not visible.

Techniques:
Detection of fog may be achieved via edge detection, along with measurements of the magnitude of the differences between colors on each side of the edge - if there is a change in these differences of magnitudes for one object, it may be a sign of fog. In addition, it is desirable to split the image into multiple sections which each have different ambient conditions, for instance if a large area shown in the image is in shadow. Object detection, and detection of distinct features, can also be used to determine common objects between multiple photos of a scene. This can be used, for instance, to compare the effectively-ambient lighting on a portion of an object in shadow to the lighting on the portion of that object facing the sun or another light source. Light snow can be detected by looking at white patterns of noise on the upper portions of objects - heavy snow will change the physical properties of these objects and their edges, and is likely beyond the scope of this project.

Potential limitations:
It will be difficult to determine the true color of an object given only a photo of that object in extreme lighting conditions. This may be resolved by relying more heavily on the average colors in a photo, or by creating a bank of known colors ("the sky is blue," "metal poles are silver," et cetera). It may also be possible to guess the base color of an object based on its shape and features using, e.g., a neural network system. In addition, extreme fog may make it difficult to rely on detected edges - in this case, some alternative object detection algorithm, possibly based on recognition of clusters of features or on large areas with distinct colors from their surroundings, can be used to find objects (and, if few edges are found, it is safe to assume very high levels of fog).

Existing work:
Much of the decades of prior work on determining lighting in scenes can be used in this project - perhaps in a lesser form, as this project is only attempting to determine lighting properties for entire photos or large sections thereof rather than for portions of the scene. As mentioned before, deep learning models may be useful to augment the ability to guess the base colors of common objects. Existing databases will also be useful in determining base object colors, as well as possibly for guessing common scene layouts for cluttered images or cases of extreme fog.

Time table:
Feb. 25 - Mar. 10: Brainstorming, initial reading of prior research, and test implementations of existing techniques and basic checks for background colors, etc.
Mar. 11 - Mar. 24: Implement core logic for lighting checks. Implement basic object recognition and rudimentary true-color detection (possibly just using hard-coded colors for testing).
Mar. 25 - Apr. 8: Improve object recognition and implement checks for fog. Potentially work on other features, such as snow detection, more advanced color inference, etc.
Apr. 9 - Apr. 23: Look for and fix bugs. Put finishing touches on any new features implemented in the preceding weeks. Possibly add ease-of-use features such as a UI.