

Report:

Impact of Image Acquisition Conditions on Quality and Computer Vision Performance

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1. Introduction

This report analyzes the effects of various environmental and technical conditions on digital image quality. The objective is to understand how **lighting**, **resolution**, and **motion** alter the characteristics of an image, such as clarity, color fidelity, and detail. Furthermore, we will discuss the implications of these variations on the performance of computer vision (CV) algorithms, assessing which images would be easier or harder for a machine to recognize and classify.

Analysis of Conditions

This section describes the expected and observed outcomes for each set of photos.

Lighting Conditions



Sunlight



Bright Light



Dim Light



Shadow

Lighting is one of the most critical factors in photography. It directly affects exposure, contrast, color, and the presence of digital noise.

- **Bright Sunlight:** Images taken in direct, bright sunlight often exhibit high contrast and hard shadows. While the subject may be well-illuminated, this can lead to "blown-out" highlights (areas of pure white with no detail) and "crushed" blacks (areas of pure black with no detail). This loss of information in the brightest and darkest parts of the image can be problematic.
- **Dim Light / Shadow:** In low-light conditions, the camera must compensate by either increasing the sensor's sensitivity (ISO) or using a longer shutter speed.
 - High ISO introduces **digital noise** (a grainy or speckled appearance), which degrades image clarity and can obscure fine details.
 - Longer shutter speeds can lead to **motion blur** if either the camera or the subject moves.
 - Colors often appear muted or less accurate in dim light.

Resolution Settings



High Resolution

Resolution refers to the number of pixels used to capture an image. A higher resolution means more detail can be recorded.

- **Normal Resolution:** This image is perfectly adequate for many uses. However, when zoomed in, fine textures, small text, or distant details may appear pixelated or blurry.
- **High Resolution:** This image captures significantly more detail. The edges are sharper, and textures are more defined. The file size is larger, but the amount of information available for analysis is much greater.



Normal Resolution

Motion



Still Image



Blurry Image

Capturing a moving subject or moving the camera during capture introduces motion blur, which can severely impact image quality.

- **Still Image:** The subject is sharp, with clearly defined edges and stable features. This represents the ideal state for object recognition.
- **Moving Image (Motion Blur):** The image appears smeared or streaked in the direction of motion. Edges, which are critical for many CV algorithms, become indistinct and difficult to locate. Key features of the object are distorted or completely lost.

Comparative Analysis and Implications for Computer Vision

The quality and characteristics of an image have a direct and significant impact on the ability of a computer vision algorithm to perform tasks like object detection, segmentation, and classification.

Easiest for Computer Vision

The **high-resolution, still image taken in bright, even light (avoiding harsh shadows)** would be the easiest for a CV algorithm to process.

- **Why?**
 - **Clear Features:** Sharp edges, well-defined textures, and accurate colors provide a rich and unambiguous set of features for the algorithm to learn and identify.
 - **High Information Density:** The high resolution ensures that even small, subtle features are captured, which can be crucial for distinguishing between similar objects (e.g., different models of cars).
 - **Low Noise:** Good lighting minimizes digital noise, ensuring the algorithm analyzes features of the actual object, not random artifacts.

Hardest for Computer Vision

The **motion-blurred image taken in dim light** would be the most difficult for a CV algorithm to process.

- **Why?**
 - **Feature Obscuration (Dim Light):** Shadows and digital noise can hide key parts of the object or create false patterns, confusing the algorithm. It becomes difficult to separate the object from the background (a task called segmentation).
 - **Edge & Texture Degradation (Motion Blur):** Convolutional Neural Networks (CNNs), a common type of CV model, rely heavily on detecting edges, corners, and textures in the early layers. Motion blur smears these fundamental features, making it nearly impossible for the algorithm to build an accurate representation of the object.
 - **Combined Negative Effects:** The combination of noise, poor color data, and smeared features presents a "worst-case scenario." The data fed to the algorithm is fundamentally corrupted, leading to a high probability of misclassification or failure to detect the object at all.

Conclusion

This experiment demonstrates that the conditions under which an image is captured are as important as the CV algorithm itself. High-quality input data—characterized by **good, even lighting, high resolution, and a lack of motion blur**—is paramount for achieving reliable and accurate results in computer vision tasks. Conversely, images suffering from poor lighting, noise, and motion blur present significant challenges that can drastically degrade performance. To mitigate these issues in real-world applications, developers often use techniques like data augmentation (artificially creating "bad" images to train the model to be more robust) and advanced image pre-processing to clean and enhance images before analysis.