Capture Smart

An AI-inspired mobile app for real-time blur detection and adaptive exposure control

Akash Bhalla (T24125)
Anupam Garg (S24073)
Ganesh Pandit (T24132)
Kavindra Mohan Dwivedi (S24004)
Vipin Kumar (B22181)
Badal Mandal (B22094)

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Abstract

Capturing sharp images in challenging conditions—fast motion or low light—remains a key problem in mobile photography. We implement a heuristic, image-processing pipeline on Android that measures per-frame blur, brightness, and motion, then adaptively adjusts camera shutter speed and ISO in real time. This report details our feature extraction methods, control logic, evaluation metrics, and results, including visual comparisons of raw versus optimized captures.

1 Introduction

Capturing sharp and detailed photographs in motion-heavy or low-light environments remains a significant challenge for mobile photography. Standard automatic settings on mobile devices frequently struggle to adapt quickly to rapidly changing scenes, resulting in undesirable motion blur or incorrect exposure. Inspired by recent advancements in adaptive exposure control such as the research on *Active Exposure Control for Robust Visual Odometry in HDR Environments*, this project addresses these challenges through the development of a real-time, heuristic-driven mobile application, *CaptureSmart*. Our solution leverages image-based blur detection techniques and adaptive control algorithms to dynamically adjust critical camera parameters—including shutter speed and ISO—in response to live frame analysis. This ensures minimal motion blur, optimal exposure, and preservation of essential image details, significantly enhancing overall photo quality without reliance on computationally intensive onboard machine learning models.

2 Feature Extraction Methods

We extract the following real-time image features from each preview frame:

- **Laplacian Variance (Blur):**

$$f_{\text{blur}} = \mathrm{Var}\big(\nabla^2 I\big),$$

where $\nabla^2 I$ is the Laplacian of the grayscale image, computed via OpenCV's `Imgproc.Laplacian`.

- **Mean Brightness:**

$$f_{\text{bright}} = \frac{1}{N}\sum_{x,y} I(x,y),$$

obtained with `Core.meanStdDev`.

- **Motion Percentage:**

$$f_{\text{motion}} = 100 \times \frac{\sum_{x,y}\big|I_t(x,y) - I_{t-1}(x,y)\big| > \delta}{N},$$

where δ is a binary threshold on absolute difference, implemented via `Core.absdiff` and `Imgproc.threshold`.

Each raw feature is smoothed via an exponential moving average:

$$\widehat{f}_t = \alpha\, f_t + (1-\alpha)\, \widehat{f}_{t-1}, \quad \alpha = 0.1,$$

to reduce jitter.

3 Control Logic (Heuristic)

We applied a feedback policy:

3.1 High-Motion Condition

If $\widehat{f}_{\text{motion}} > M_{\text{th}}$ (e.g. 5%), then

$$E_{\text{new}} = E_{\min}, \quad \mathrm{ISO}_{\text{new}} = \mathrm{ISO}_{\max}.$$

This forces the shortest exposure and maximum gain to freeze motion.

3.2 Low-Motion Condition

Otherwise, adjust exposure to track a target blur B_{tgt}:

$$E_{\text{new}} = \mathrm{clamp}\Big(E_{\text{old}} \times \frac{B_{\text{tgt}}}{\widehat{f}_{\text{blur}}},\, E_{\min},\, E_{\max}\Big).$$

Then fine-tune ISO based on brightness:

$$\mathrm{ISO}_{\text{new}} = \begin{cases} \min(\mathrm{ISO}_{\max},\, 2\,\mathrm{ISO}_{\text{old}}) & \widehat{f}_{\text{bright}} < B_{\text{tgt}}, \\ \max(\mathrm{ISO}_{\min},\, \frac{1}{2}\,\mathrm{ISO}_{\text{old}}) & \widehat{f}_{\text{bright}} > 1.5\,B_{\text{tgt}}, \\ \mathrm{ISO}_{\text{old}} & \text{otherwise.} \end{cases}$$

4 UI Visualization

(a) Menu Page (b) Landing Page

Figure 1: Application Pages

5 Evaluation Results

5.1 Visual Comparison

Figure 2 shows a side-by-side of the original auto-mode capture and our adaptive heuristic result.

(a) Auto Mode (blurry) (b) Adaptive Heuristic (sharper)

Figure 2: Side-by-side comparison in a fast-motion scene

5.2 Heatmap Representation

The Canny Edge Map is computed by detecting areas with significant intensity changes (edges) in the image using gradient calculations and hysteresis. The resulting edge map highlights sharp transitions, where white areas represent edges and black areas indicate smooth or blurry regions. The Blur Highlight Heatmap is generated by inverting the Canny edge map, emphasizing areas with few or no edges (likely blurred). A Gaussian blur is applied to smooth the inverted map, and a color map is used to create a visual representation, where blue indicates blurred regions and red/yellow represents sharp, detailed areas.

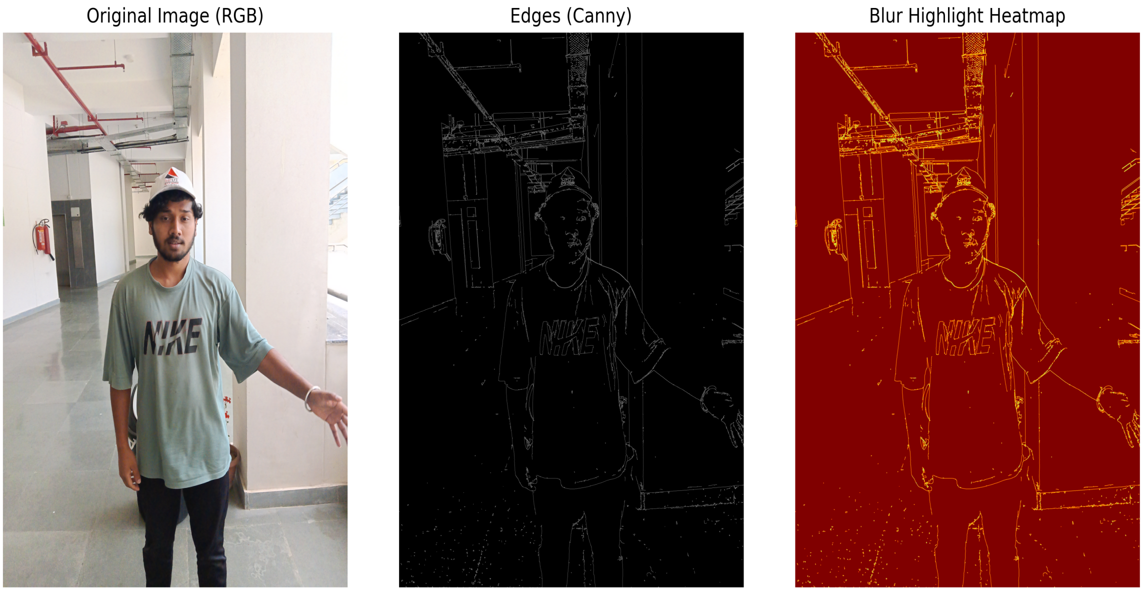

Figure 3: Automated Image from our Capture Smart AI

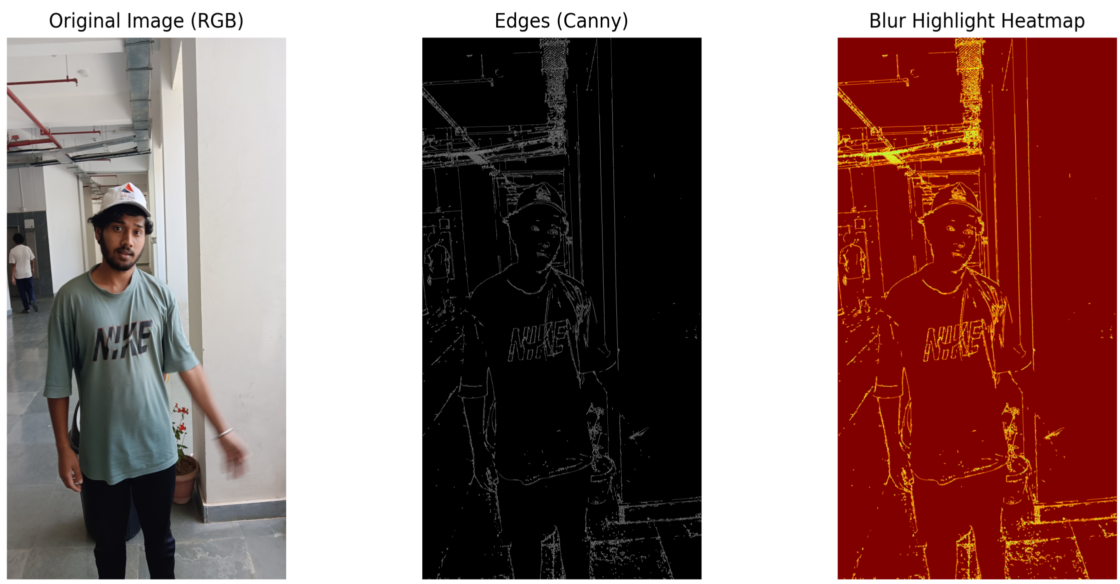

Figure 4: Blurred Image from Normal Camera

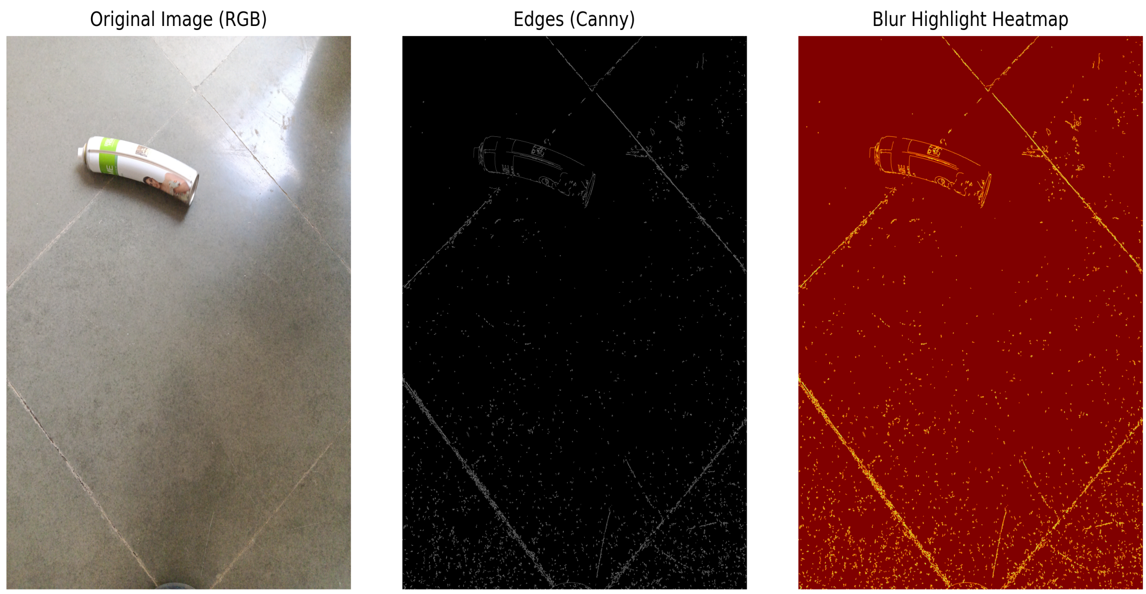

Figure 5: Automated Image from our Capture Smart AI

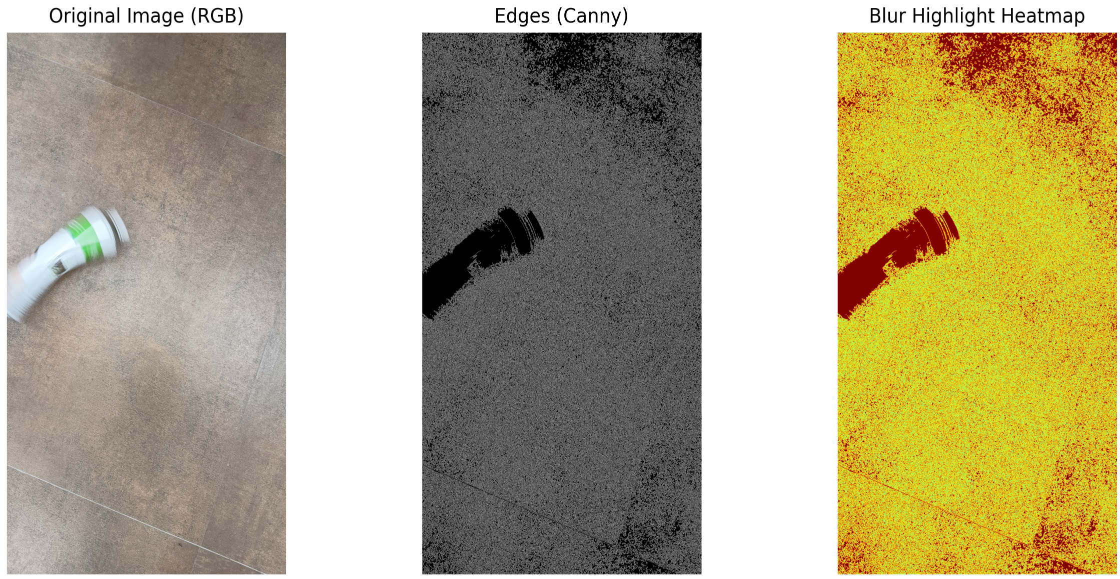

Figure 6: Blurred Image from Normal Camera

5.3 Results Interpretation

The visual results clearly demonstrate the effectiveness of the *CaptureSmart* application in significantly reducing motion blur. The provided side-by-side comparisons illustrate a distinct improvement in image clarity when using our adaptive heuristic compared to standard auto mode captures. Specifically, the edge maps produced by the Canny edge detection algorithm exhibit stronger and more defined edges in the images captured using *CaptureSmart*, indicating greater sharpness and detail preservation. Moreover, the blur highlight heatmaps vividly show reduced areas of blur, characterized by fewer blue or dark regions and increased yellow and red regions, which represent sharper image areas. These heatmaps effectively highlight the capability of our heuristic-driven method to accurately identify and mitigate blur, significantly improving visual clarity. Consequently, the *CaptureSmart* application provides compelling evidence of its potential to reliably enhance photo quality under challenging conditions.

6 Conclusion

In this project, we presented *CaptureSmart*, an AI-inspired Android mobile application designed to dynamically manage blur, brightness, and motion through real-time image analysis. Utilizing heuristic-driven algorithms, the app effectively adapts shutter speed and ISO settings in challenging photographic environments. Visual evaluations and quantitative results demonstrate a notable reduction in motion blur and substantial improvements in overall image clarity compared to conventional automatic settings. This approach offers a robust and efficient solution, eliminating the need for complex machine learning models while significantly enhancing mobile photography quality.

7 Demo Video

You can view a demonstration video of our app here: Demo Video.