Analyzing Sensor Quantization of RAW Images for Visual SLAM

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ABSTRACT

- SLAM can be used to enable low-power robotic navigation.
- Visual SLAM algorithms use images produced through the image sensor processing pipeline which is optimized for aesthetic photography.
- We bypass the ISP and vary sensor quantization which results in an 88% energy savings.
- We also introduce gradient-based quantization

METHODS

Implement ORB-SLAM2 and LSD-SLAM with the TUM RGB-D video dataset. Record absolute trajectory error (ATE): difference between points of true and estimated trajectory

RAW data: We leverage the Configurable & Reversible Imaging Pipeline (CRIP) to convert PNG images to RAW [2]. The ISP chip is eliminated (demosaicing, denoising, white balancing, color transforms, and tone mapping).

Linear quantization: Convert raw data with linear analog-to-digital (ADC) converter before performing SLAM

Logarithmic quantization: Convert raw data with logarithmic ADC which better represents images

Gradient-based quantization: Our algorithm encodes regions with high-intensity gradient with higher bit values and lower gradient regions with lower bit values. Essentially, this method preserves regions that are used for tracking, but downgrades non-salient regions to lower bits.

RESULTS

Resolution: Simulated four decreased resolutions. A ⅓ decrease in resolution resulted in a factor of 10 increase in ATE.

Frame rate: 15 fps resulted in no change to ATE, below 7.5 fps failed to track

Overall, 5 bit logarithmic quantization results in an 88% energy savings with an average ATE of ~2 cm.

Gradient-based quantization achieves an ATE comparable to 7-8 bit logarithmic quantization at an average of only 4-5 bits.

This method saves effectively 3-4 bits in energy compared to logarithmic.

REFERENCES


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