Aerial Rock Fragmentation Analysis in Low-Light Condition Using UAV Technology

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Forecast

We use UAV technology to frequently measure rock fragmentation.

In this work we found that:

- Lighting conditions greatly impact photographic analysis accuracy
- Artificial lighting applied evenly can improve prediction accuracy and enable measurement in low light conditions

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Outline

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Motivation

Post-blast rock fragmentation influences:

- Comminution energy consumption
- Mill throughput rates
- Digging and hauling equipment efficiency

Measuring it is important for optimizing a mining operation.

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Motivation

Unmanned Aerial Vehicle (UAV) technology can measure rock fragmentation:

- Provide higher spatial- and temporal-resolution data
- Automate data collection
- Collect from typically inaccessible and hazardous areas
- Improve safety for technicians
- Frequently measure surface to predict internal distribution

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Problem Statement

To frequently measure rock fragmentation consider:

- Night shifts in surface mines
- Underground working conditions

However, UAVs equipped with common cameras in poor lighting:

- Difficult to delineate particles

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Problem Statement

Two questions this work investigates:

- How much does poor lighting effect accuracy?
- Can artificial lighting reduce this effect?

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Related Work

Limitations for photographic and 3D measurement of rock fragmentation:

Limit	Photographic	3D techniques
Measure surface not internal distribution	✓	✓
Particle delineation error	✓	✓
Perspective distortion	✓	
Inability to meaningfully detect fines	✓	

Related Work

3D techniques using LIDAR and stereo imaging control some limitations, however:

- Have not enabled automated measurement
- Currently capture from fixed locations
- Addition to UAV can be expensive

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Methods

Compare UAV rock fragmentation measurement using commercial image analysis software with sieve analysis in different lighting conditions for:

- Controlled lab environment
- Outdoor Experiment

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Methods

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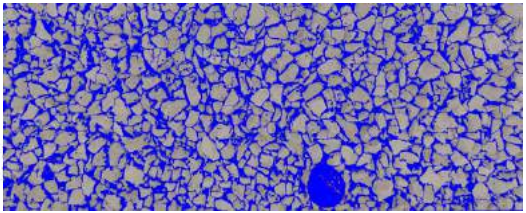
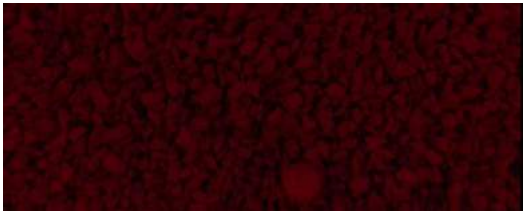
Results

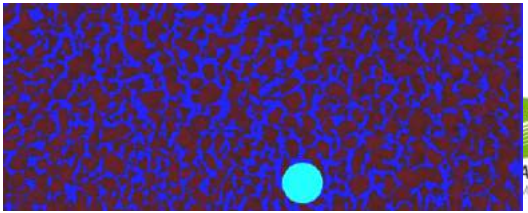
Raw and delineated photos in ideal (a) and dark (b) lighting.

a)



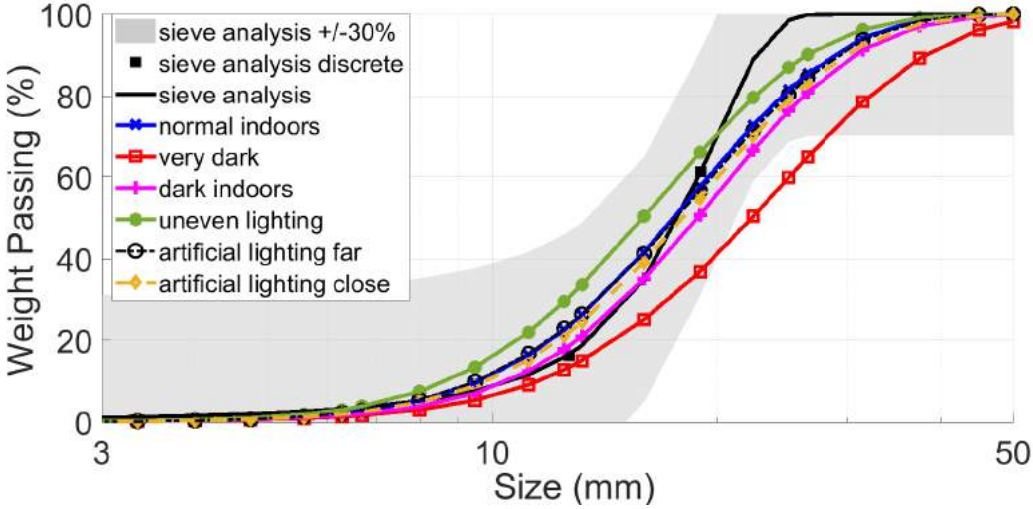
b)





Results

Rock fragmentation analysis results for indoor environment.



Results

Illuminance Amount of luminous flux per unit area [lx]

Error Area between sieve and estimate curves [percent passing $\times$ log(mm)]

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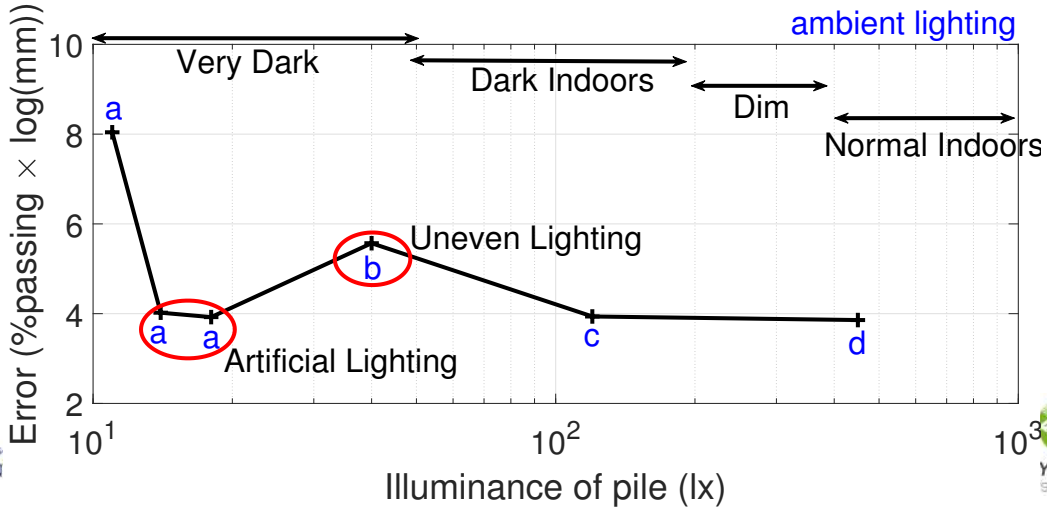
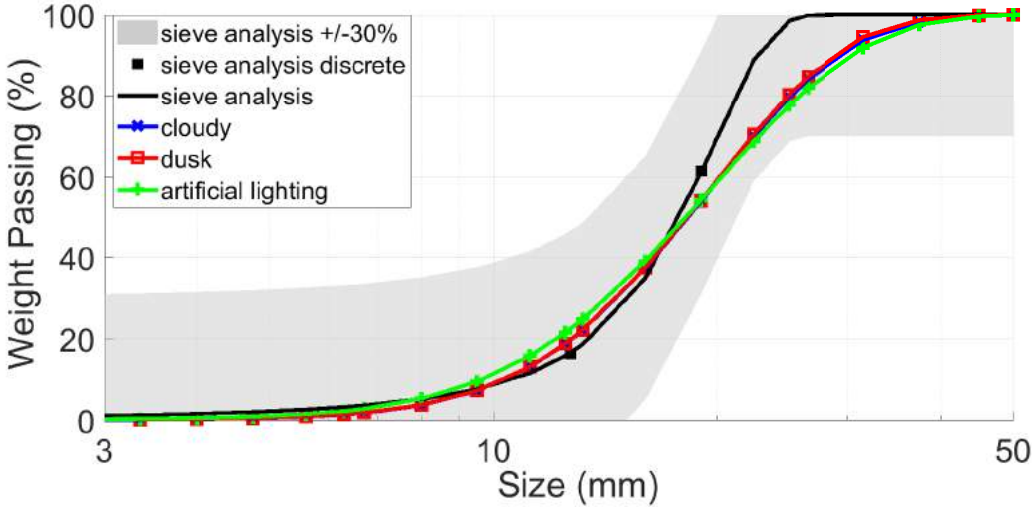
Results

Distribution error plotted with illuminance measurement for indoor environment.



Results

Rock fragmentation analysis results for outdoor experiment.



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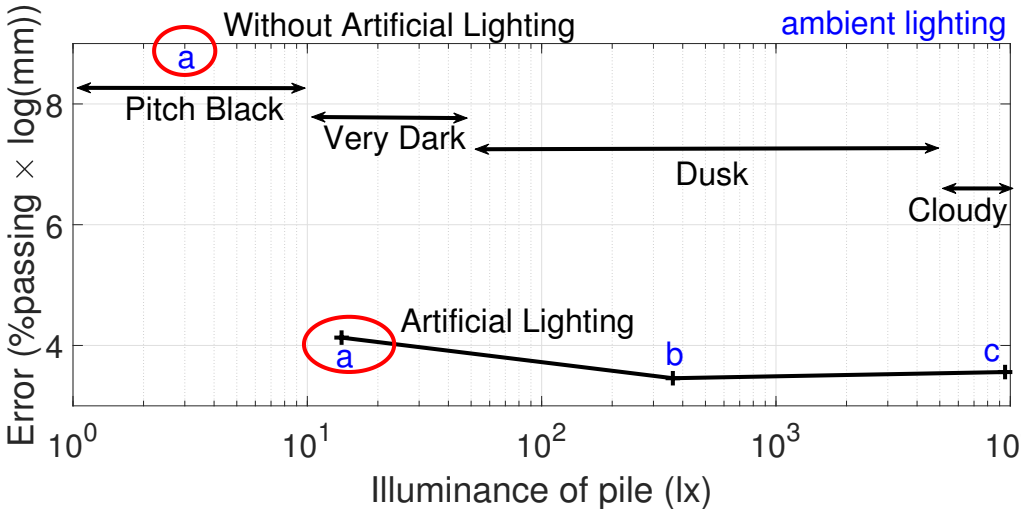

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Summary

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Future Work

Items that have been raised during this work:

- Test concepts in a mining environment
- Incorporate measurement uncertainty into analysis
- Configure better cameras (ex. high dynamic range)
- Light inaccessible areas
- Increase control over image analysis
- Understand trade-offs using 3D techniques

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Thank you! Thomas Bamford
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