Doing More with Less: Optimizing Image Quality and Stereo Depth at the Edge

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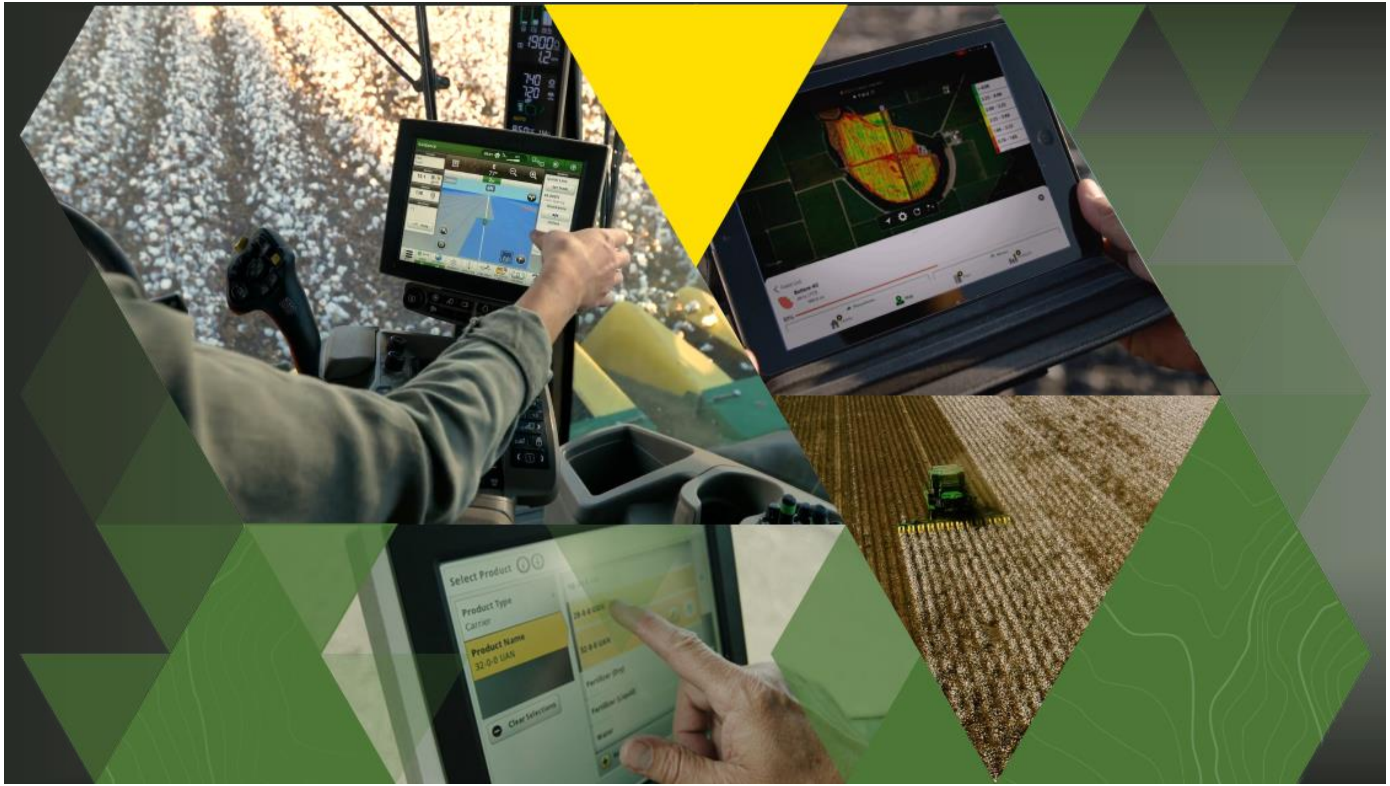
Automation & Autonomy

John Deere

Overview

- John Deere Background
- Image Quality Considerations
- Stereo Method Comparisons
- Q&A

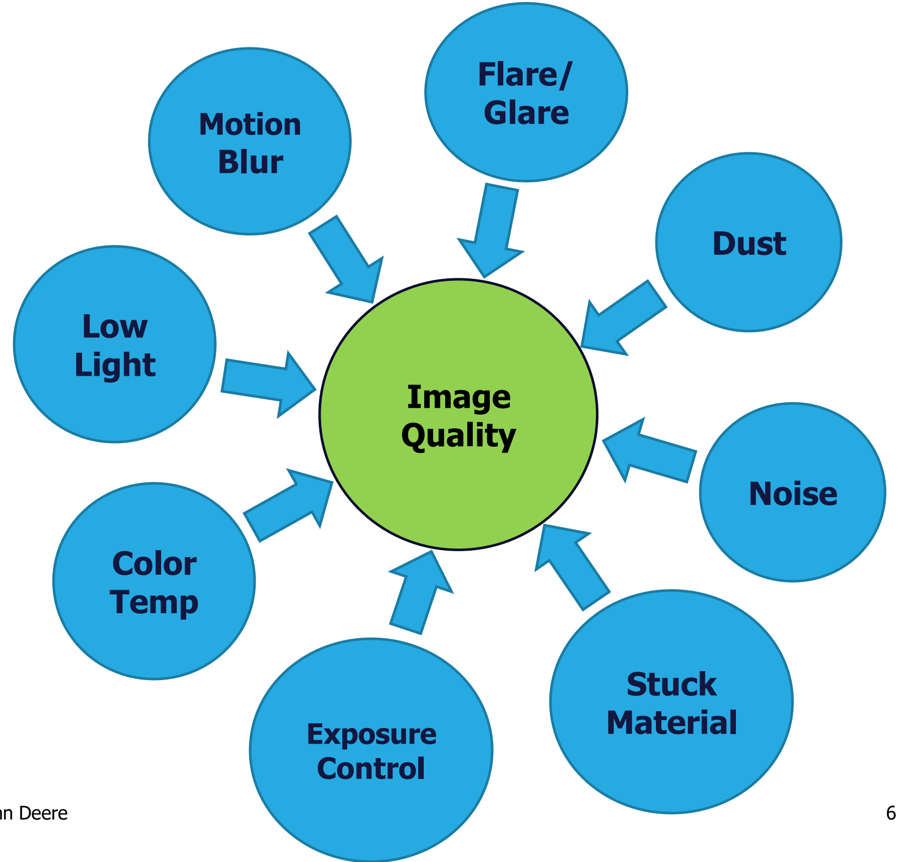
Technology at John Deere



What Makes A Good Image For Computer Vision & Machine Learning?

[1]

[2]



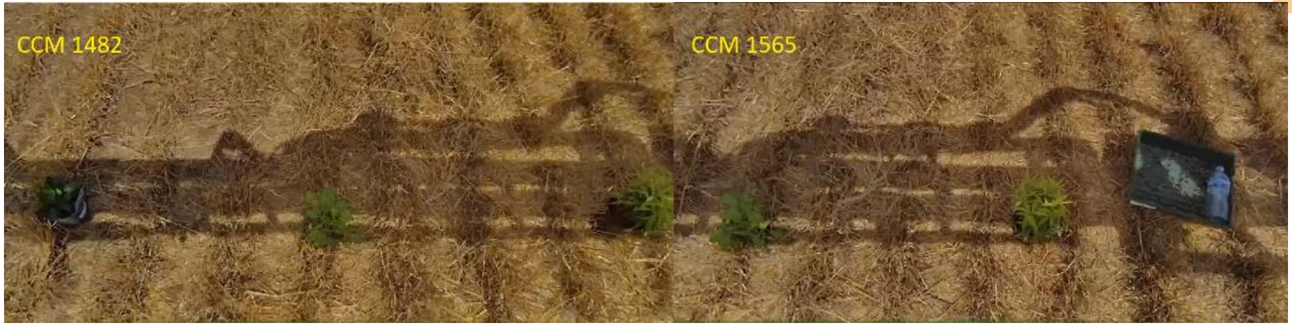
See & Spray Select – Use Case

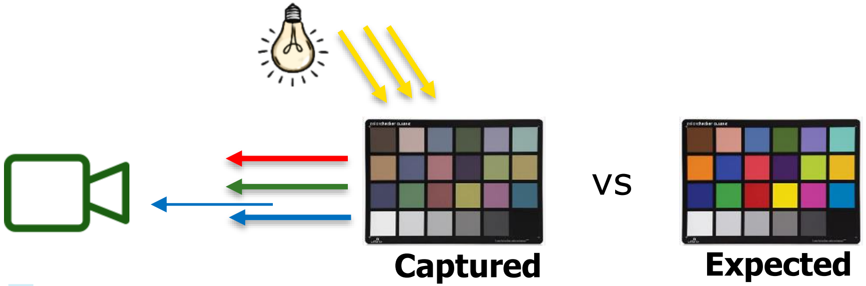
Configuration

- 120 ft boom
- 96 nozzles
- 34 cameras
- 5 controllers

- @ 12.5 mph

Color Correction

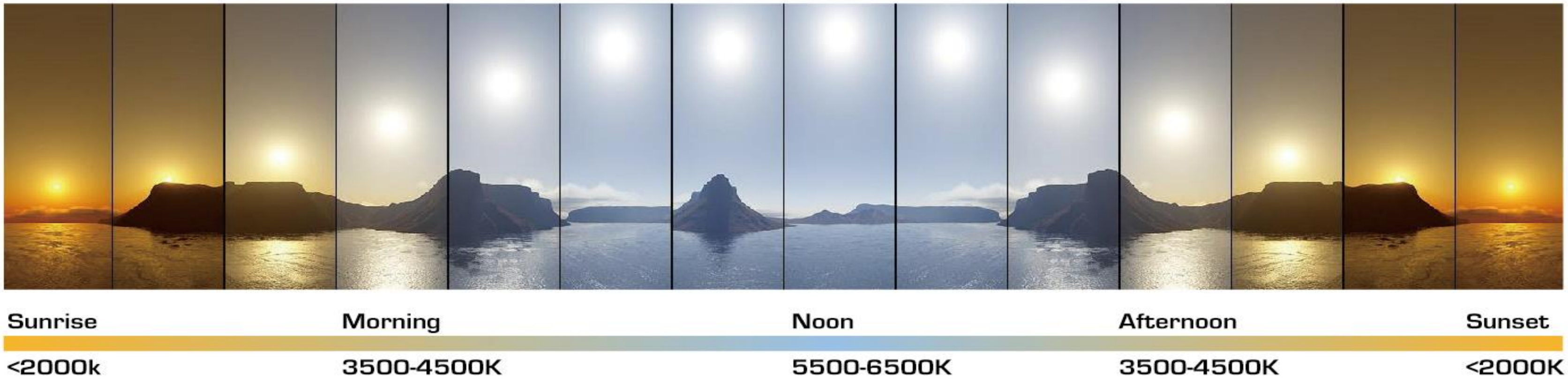




$$\underbrace{\begin{pmatrix} m1 & m2 & m3 \\ m4 & m5 & m6 \\ m7 & m8 & m9 \end{pmatrix} + \begin{pmatrix} c1 \\ c2 \\ c3 \end{pmatrix}}_{\textbf{CCM}}$$

White Balance → **Bayer Interpolation** → **CCM** → **Gamma** → **Color Conversion**

Ambient Light Inconsistency



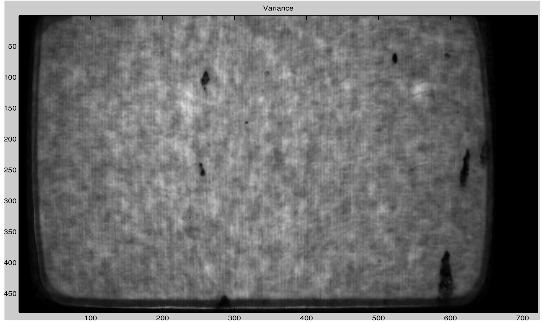
[3]

- The change of color temperature through the day will cause the image to appear differently at different times of the day, hence make it challenging to develop an algorithm that deal with the color inconsistency.

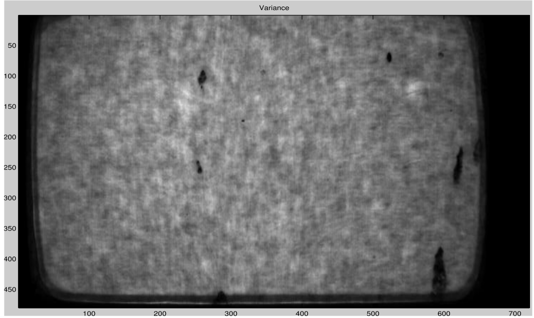
Stuck Material On The Lens

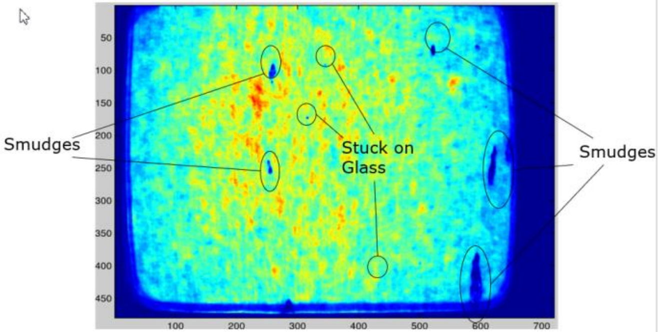
[4]

- Stuck Material maybe hard to detect especially when dealing with translucent material.
- Not all stuck material necessarily impact the image processing.



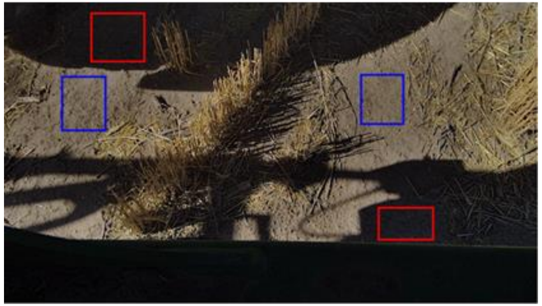
Stuck Material On The Lens

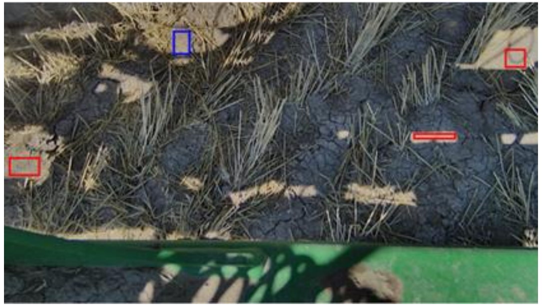


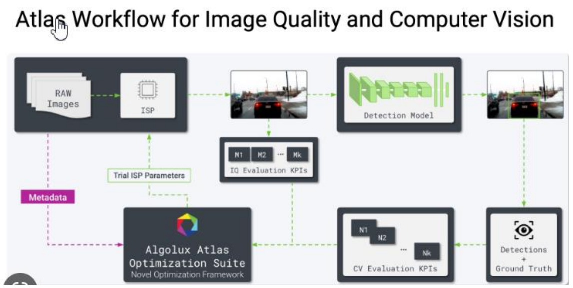


- Computing a Stuck Material mask Make it easier to estimate the impact on the viewing ROI
- The impact may be different based on application

Dealing With Shadows





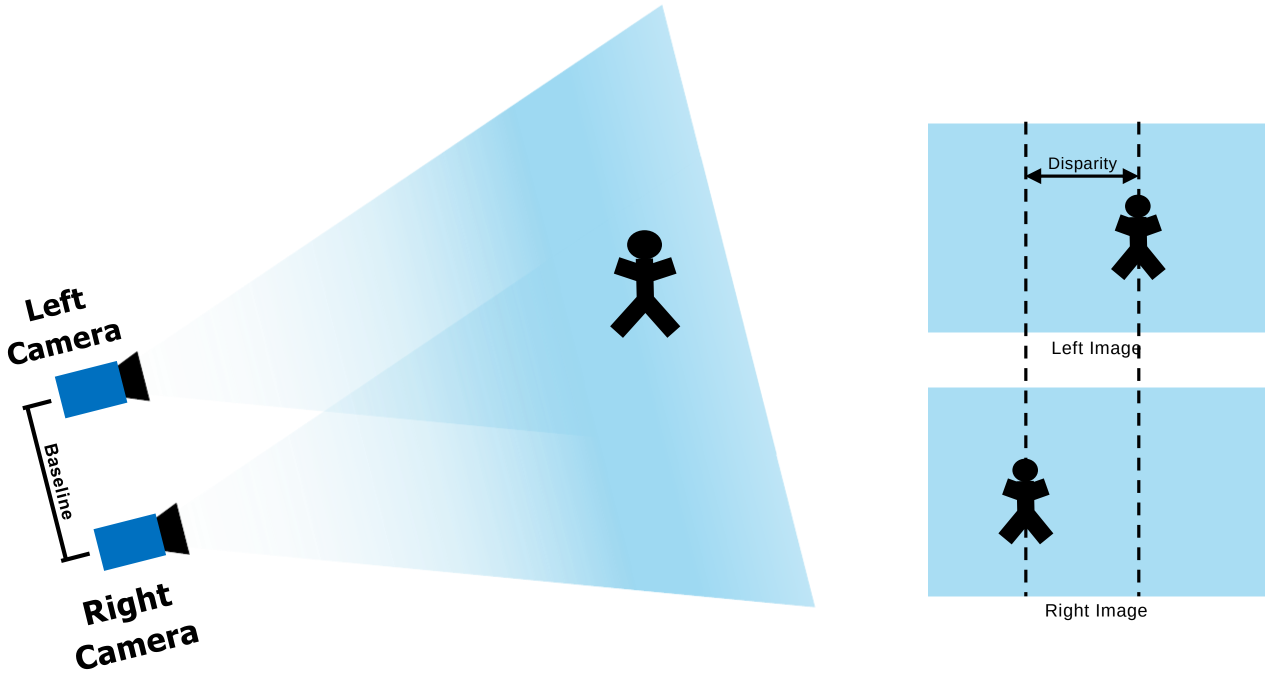


[5] Atlas Algolux

[6] Visionary.AI

- Tunning the ISP settings may be challenging or impossible to get the optimum setting to deal with issues such as shadows.

Stereo Vision

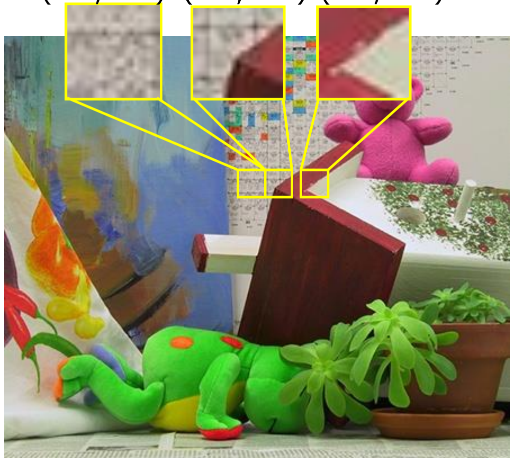


Stereo Correspondence

Disparity: $dx = x_l - x_r = 274 - 242 = 32$

Distance: $D = fB/dx$ = (focal length x baseline) / disparity

Left Image



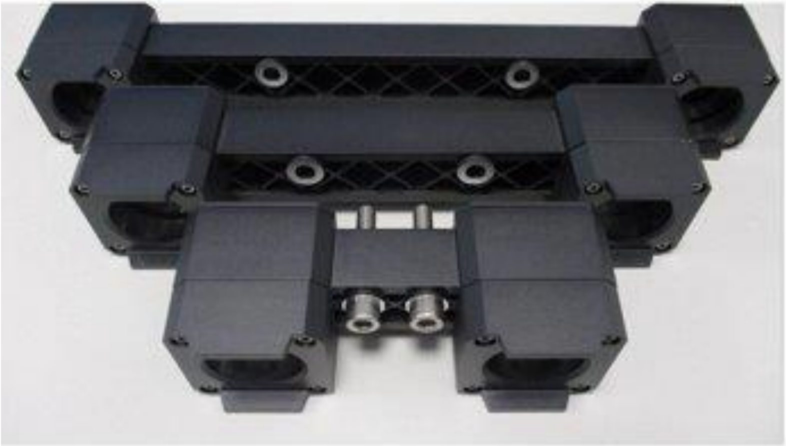
Right Image

[7]

Stereo Disparity Image

[7]

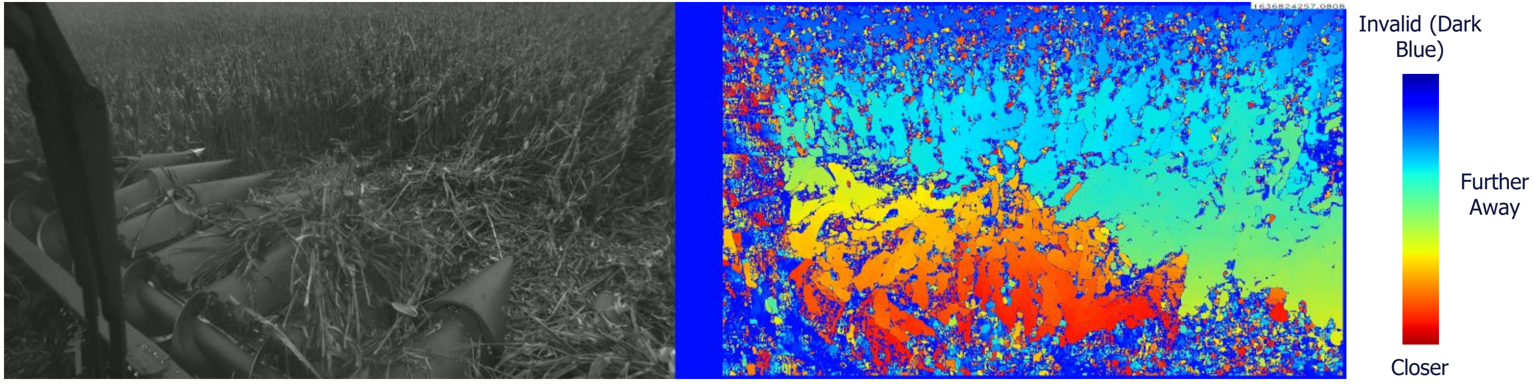
Stereo At John Deere



Various Baselines and Imagers

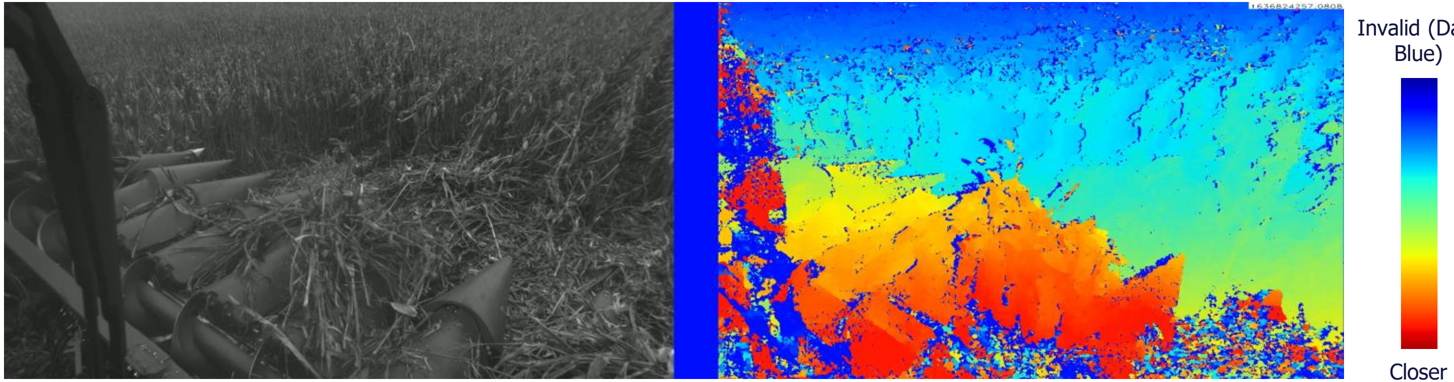
Various Image & Video Processors (FPGA or GPU)

Block Matching Example – Minimal Filtering



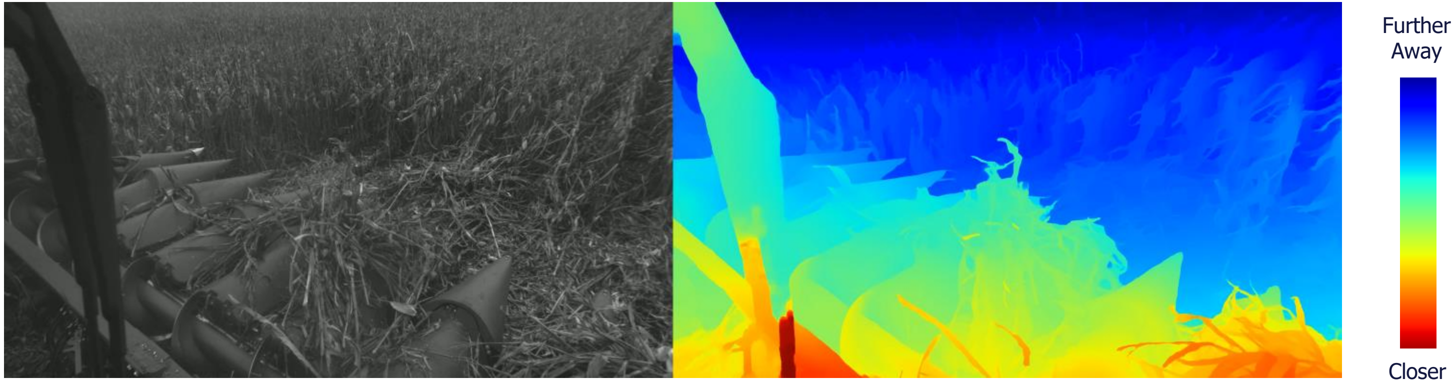
OpenCV StereoBM [8]

Semi-Global Block Matching



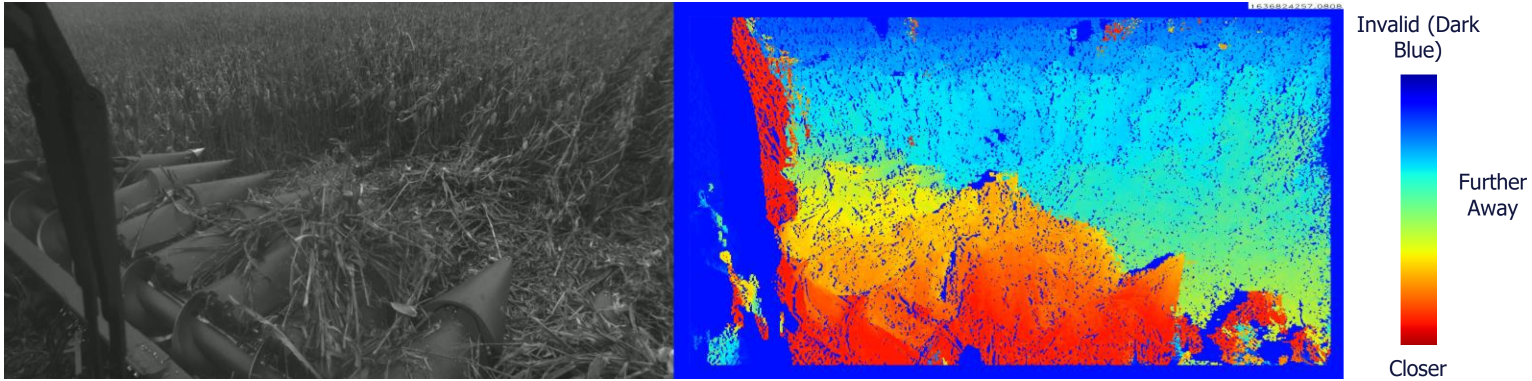
OpenCV StereoSGBM [9]

Neural Net Based Stereo Approach (Machine Learning – RAFT)



iRaftStereo_RVC [10]

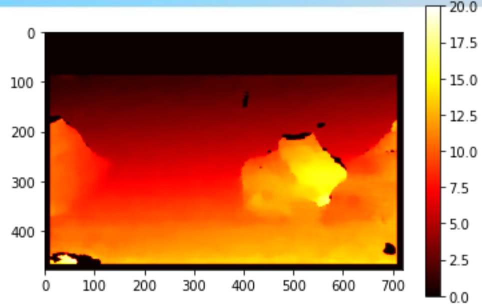
Alternate Block Matching Example



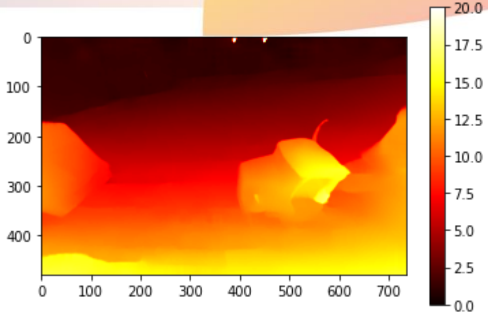
Alternate BM

Stereo Method Differences

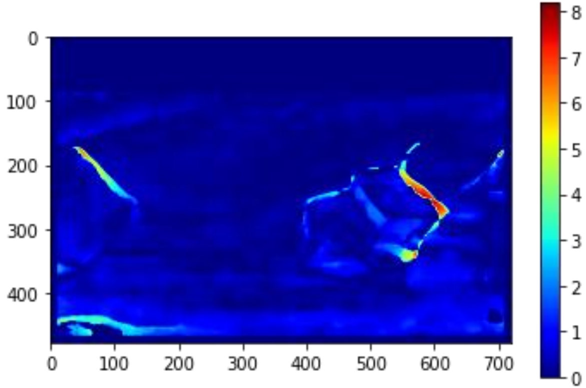
Reference Image



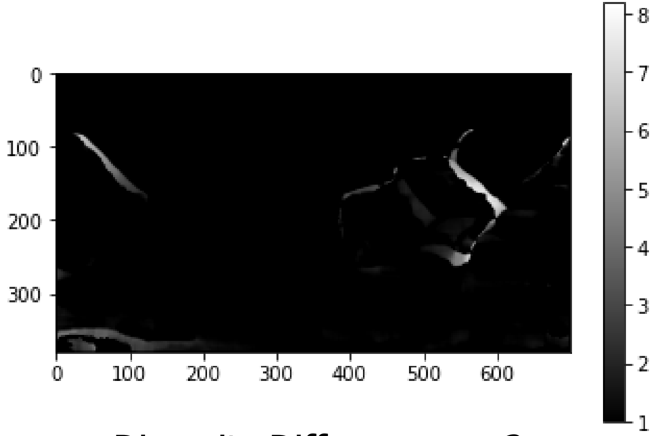
Block Matching



AI Matching (RAFT)

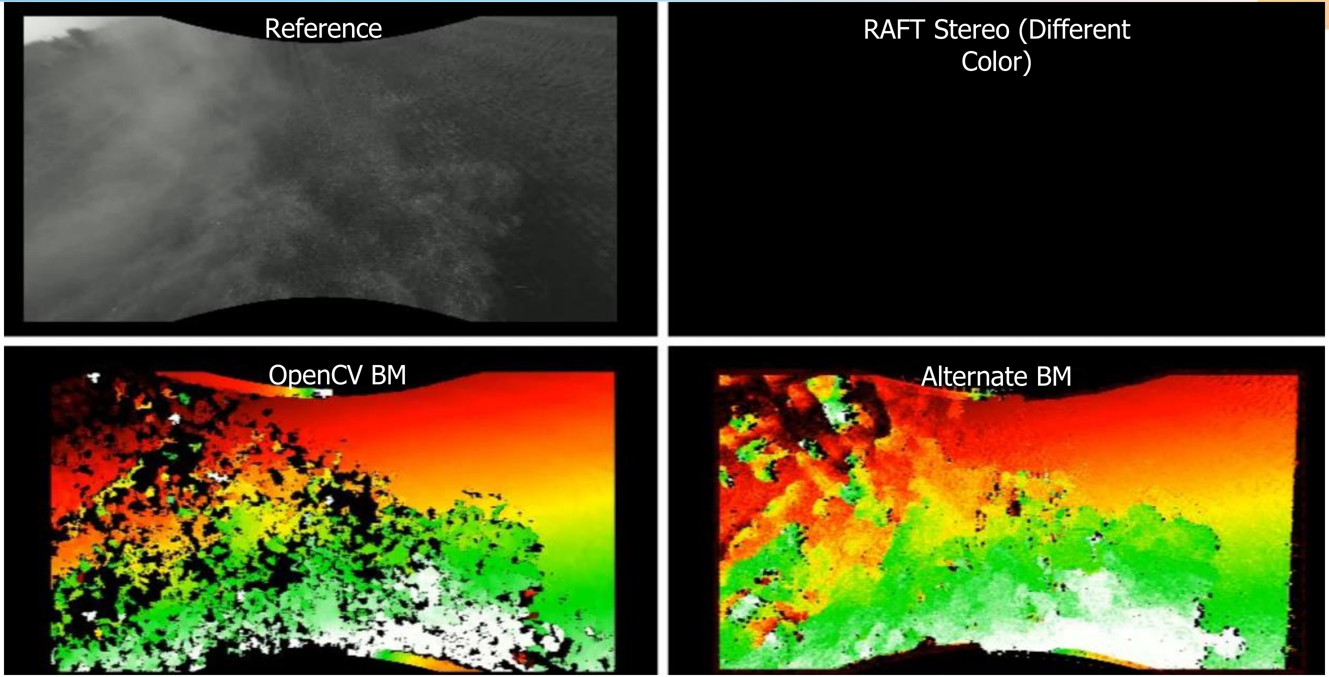


Pixel by Pixel Disparity Differences



Disparity Differences > 2

Additional Examples with Various Stereo Comparisons



- "Alternate BM" most efficient method & meets requirements for several John Deere applications.
- ML approach has higher precision capability, but greater chance of error for low confidence areas.
- Many use cases are already doing a Computer Vision or Machine Learning Algorithm On Image(s)

Conclusions & Recommendations

Strive to do More with Less

- Start with the Worst Case & Strive for the Best Case (Data, Application Requirements, & Compute)
- Characterize Your Image Conditions for Outdoor Environments
- Higher Computation Stereo Has More Resolution & Accuracy Potential, But Also Potential for Error
- Higher Computation Stereo Improves Edges – Do you use Depth for your Edges?

References

Image Quality References:

1. https://www.adobe.com/uk/creativecloud/photography/discover/color-changer.html
2. https://www.photoreview.com.au/tips/shooting/iso-and-image-quality/
3. ttps://www.lumistrips.com/lumistrips-blog/color-temperature-explained/
4. www.lensrentals.com
5. https://algolux.com/newsroom/algolux-brings-atlas-to-the-cloud-to-democratize-camera-isp-optimization-for-computer-vision/
6. https://www.visionary.ai/

Stereo References:

7. Stereo Reference Example Image *from* https://vision.middlebury.edu/stereo/data/scenes2003/
8. OpenCV Stereo Block Matching *from* opencv/stereobm.cpp
9. OpenCV Semi Global Block Matching *from* opencv/stereosgbm.cpp
10. RAFT Stereo *from* princeton-vl/RAFT-Stereo

Special "Thanks" for Content & Contributions

Zach Bonefas, Nick Butts, Ruveen Perera, & Vincenzo Macri