GPU + Drones + 3D Imaging for Precision Farming and Construction

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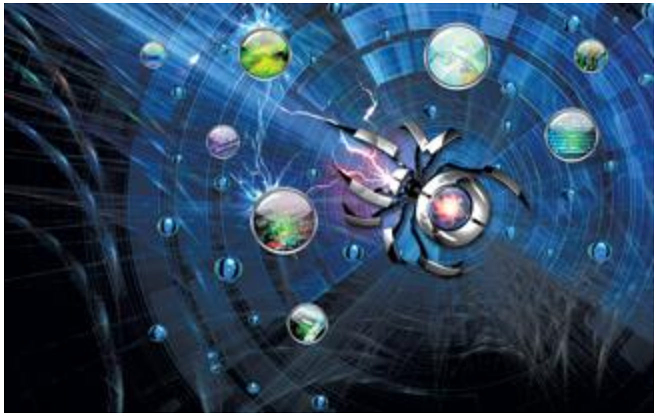

Democratization of 3D Imaging Technology

– Drones and GPU make 3D imaging affordable

- Agriculture
- Disaster management
- Surveying
- Animal observation
- Land fill survey
- Forestry conservation
- Environment management
- Mining
- Construction

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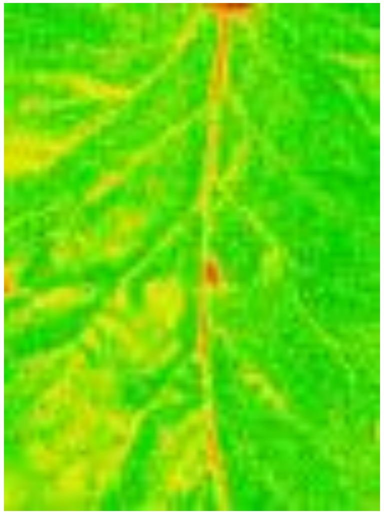
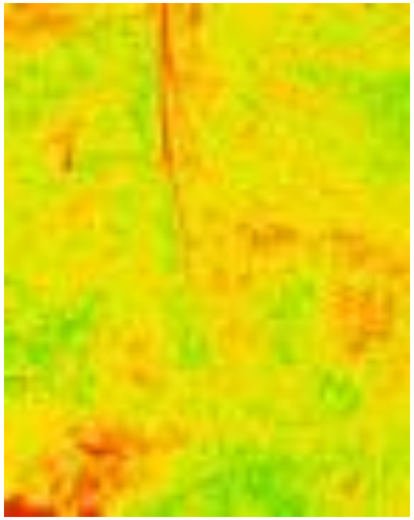
Farmer and His Rice Paddy

Scientific and Precision Farming

My brother can see these

My brother cannot can see these





Transfer farming knowledge into simple instructions for farmers

Precision Farming Variable Rate Fertilizer

- Crop type: Wheat
- Area: 47.5 acres
- Conventional cost: $4,647
- Variable rate cost: $3,385

- 27% Saving
- *David Dvorak – Field of View LLC*

27% saving on fertilizer

High Tech for Farmers

Drones + 3D Remote Sensing + GPU help farmers

What

When

How

scientifically, precisely, timely, and economically

4 Million Miles of Public Roads in US

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Design and Inspect Bridges

- Bring a 3D reality into office to design bridges
  - 3D images from drones
  - GPU 3D image processing
- Inspect bridges
  - 3D images from drones
  - GPU 3D image processing

Cheaper and Safer

GPU Makes 3D Image Processing Affordable

- Drones make images affordable and available
- GPU makes 3D image processing economical
- CUDA implementation of our 3D point clouds generation from drone images is much faster than CPU (7 times)
- Many algorithms can generate 3D point clouds from images
  - How accurate?
  - Blunder free?

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Blunder Detection and Removal

- Assuming 1% of 3D points are blunders, how to detect them?
- One of key 3D imaging algorithms
- Use a semi-globe smoothness constraint to detect blunders
- When image pixel values are similar of adjacent points, enforce a smoothness constraint
- Use “reliability index” as weight
- This is a typical NP-hard algorithm
- Use a number of discrete directions instead

Reliability Index

- Number of consistent matches
  - ASM uses up to three different algorithms to match a pixel
  - When all three matches have consistent results, it is high reliability
- Visibility
  - On steep slopes or vertical building sides
  - Epipolar rectification is on to a horizontal plane
  - Visibility is the min visibility value of both stereo images
  - Line of sight is also considered
- Shadow
  - In shadow area, matches with lower elevation is more reliable than matches with higher elevation
- FOM (Figure of Merit)

GPU Timing vs. CPU Timing

CPU	564	440	376	560	500	436
GPU	125	78	47	140	125	125
CPU/GPU	4.5	5.6	8.0	4.0	4.0	3.5

Average speed up of 4.9 times

Single CPU thread 3.0 GHz

Quadro K5000

With K6000 card, the expected speed up is 9 times

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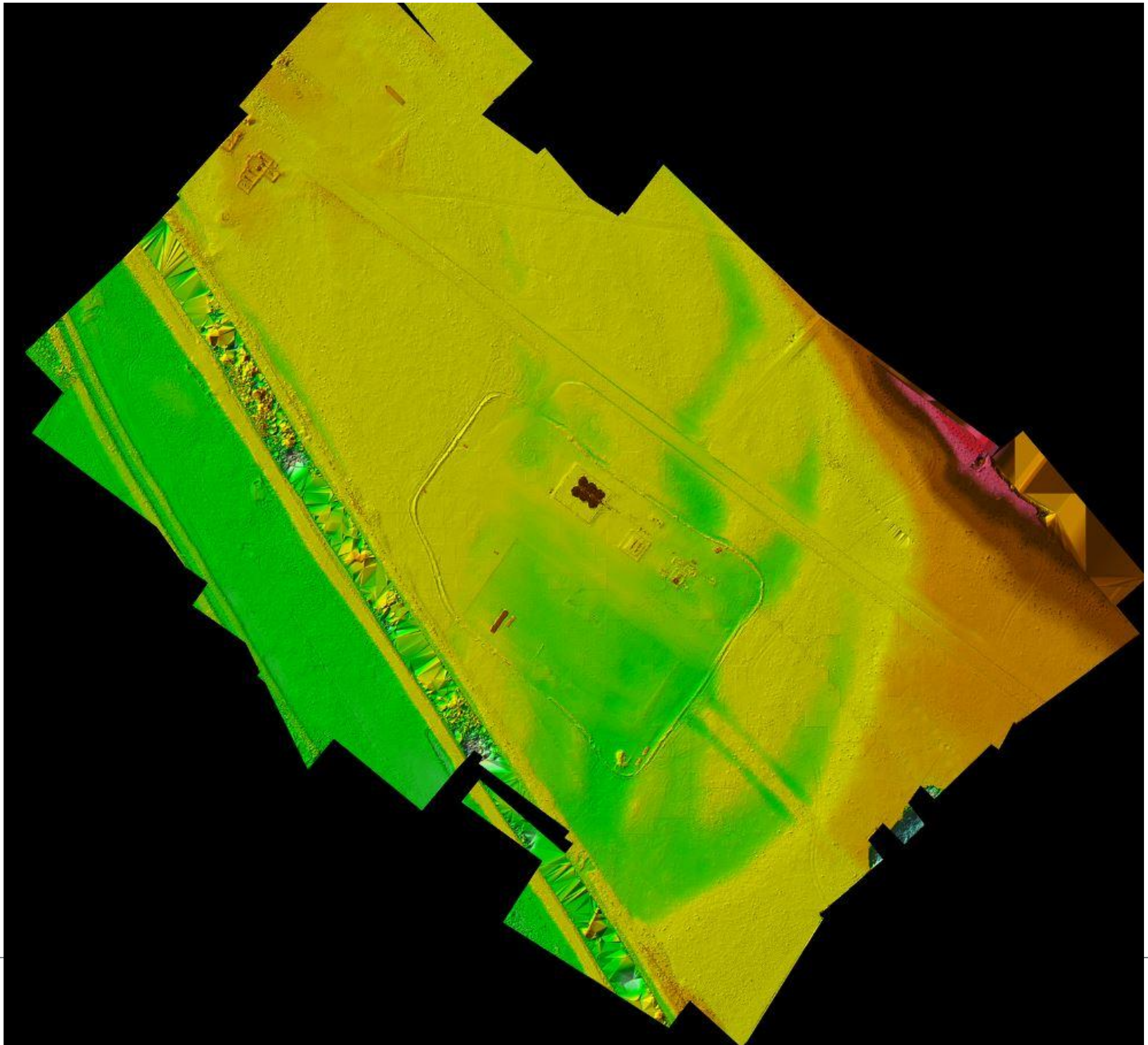
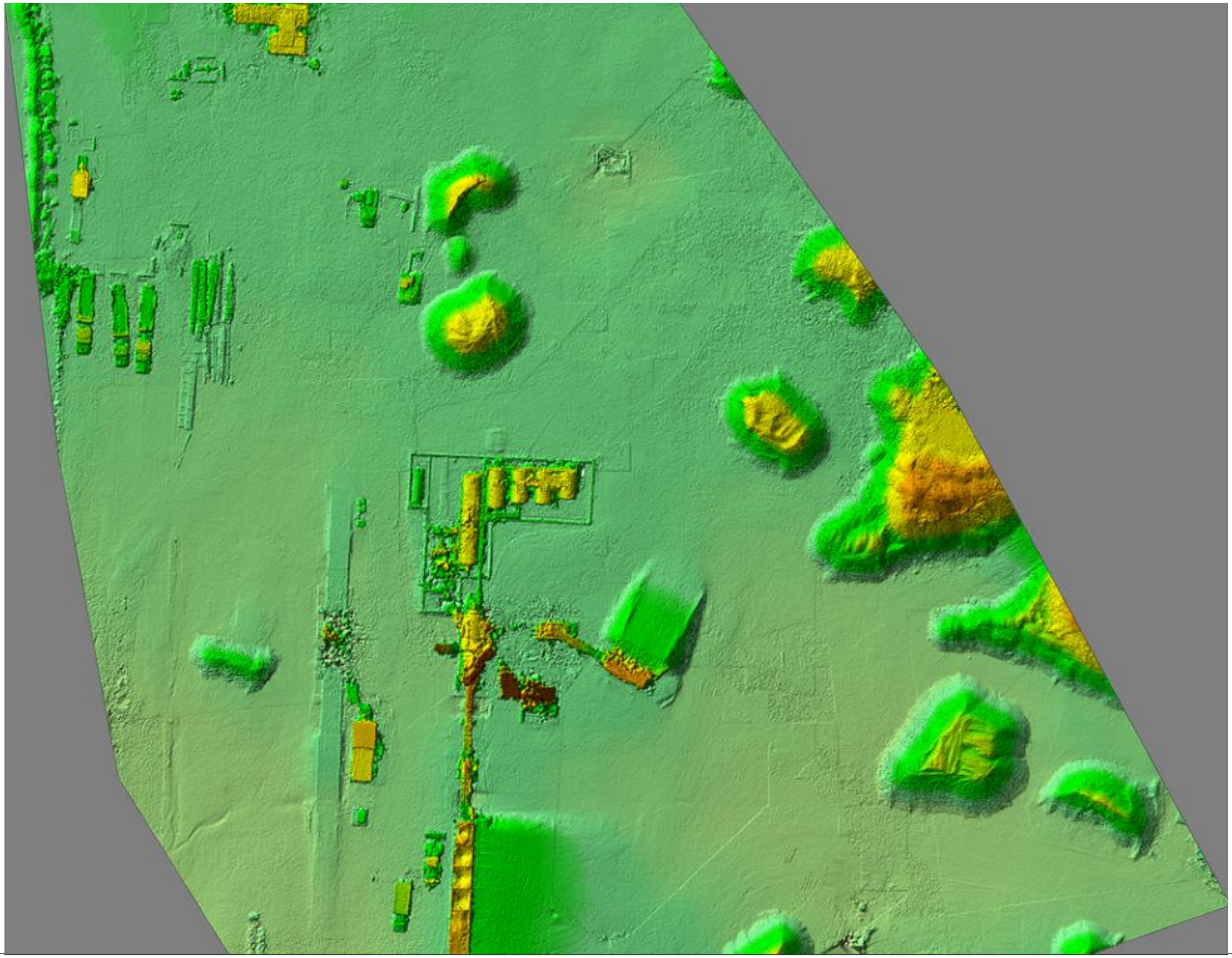
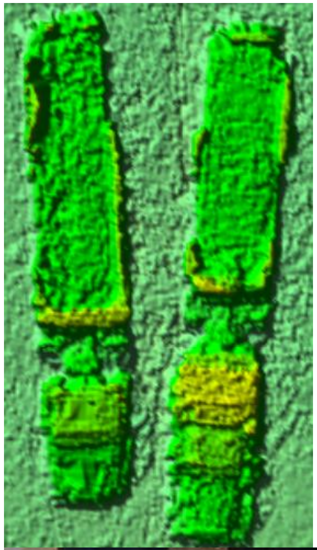
True Color 3D Point Clouds

178 UAV Images (GSD = 2cm)

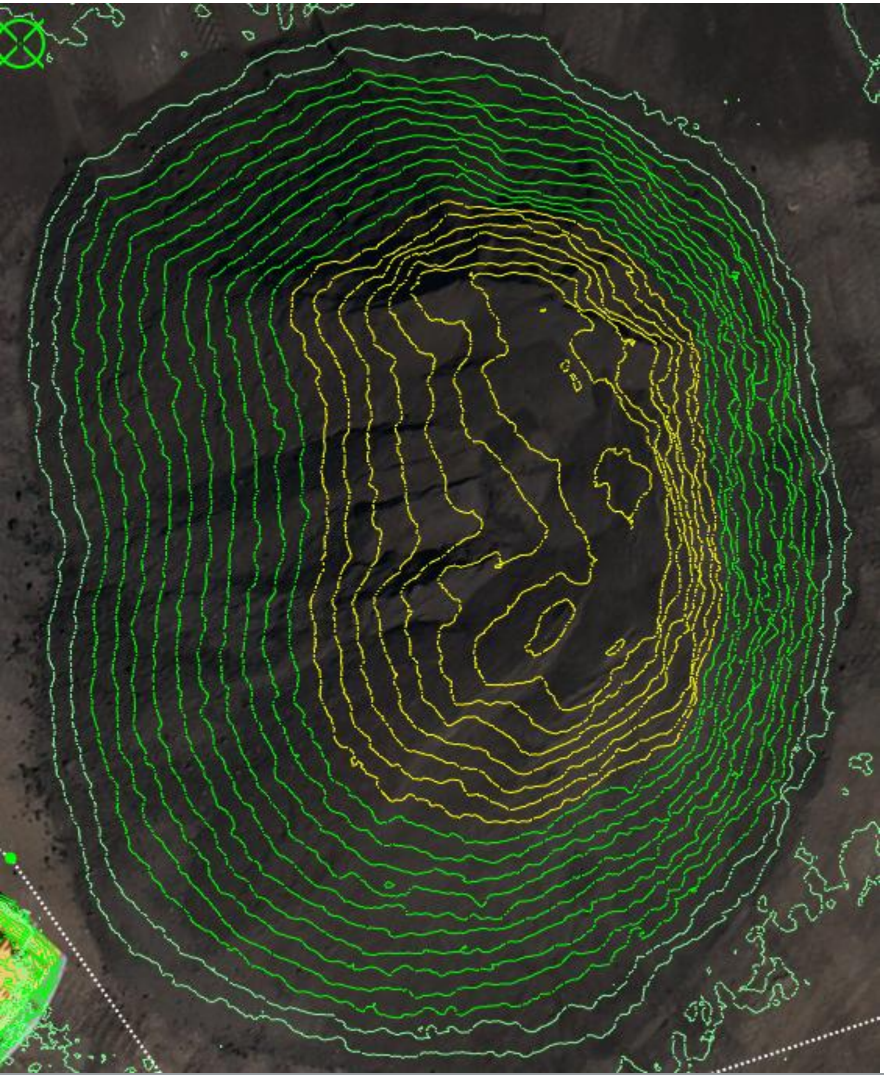


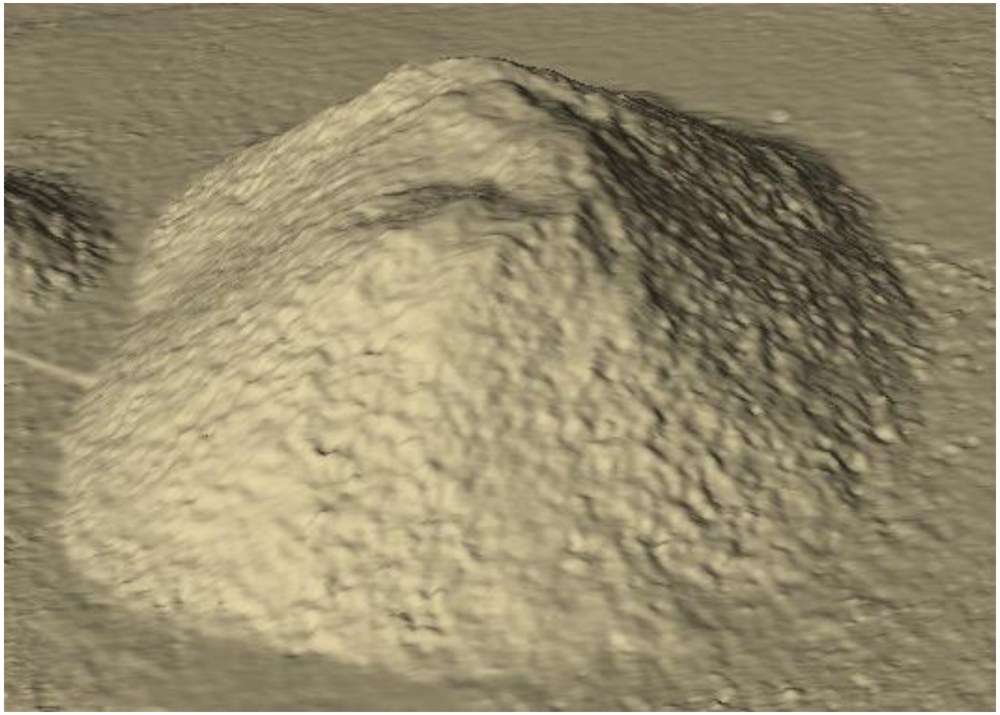
1.7 cm UAV Images





3.5 cm Precision





Images: courtesy Lewis, GeoCue

Thank you!

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