Image Analysis for Accelerated Phenomics

Chuong Nguyen et al
COE Postdoctoral Fellow, Quantitative Imaging, CMIS Acton, Canberra
11 October 2011
Image analysis pipeline for Plant Phenomics

Multi-view data acquisition for plants

Local & remote image processing

Source: Sirault (2011) Phenomics collaborative framework

PlantScan

LiDARs, cameras

DAILY STORAGE
Production is ~1.5 TBytes/day

Image processing for Accelerated Phenomics
Multi-view 3D reconstruction

This is a multiple process:

- Camera calibration → camera focal length, optical distortion
- Image undistortion → image rectification (straight line is straight)
- Camera pose estimation → camera projection matrix
- Image segmentation → object silhouettes
- Volume reconstruction using
  - Visual hull or “shape from silhouette”,
  - Space carving or voxel colouring,
  - Patch-based multi-view stereo
Multi-view 3D reconstruction - Calibration

Calibration with calibration targets:

- Camera calibration → *camera focal length, optical distortion*
- Image undistortion → *image rectification (straight line is straight)*
- Camera pose estimation → *camera projection matrix*

"Calibration tree"  

Exaggerated undistortion

3DSOM

Camera poses

Image processing for Accelerated Phenomics
Multi-view 3D reconstruction – Auto calibration

Auto/self calibration using Bundler
(http://phototour.cs.washington.edu/bundler/):

- Scale Invariant Feature Transformation (SIFT) detection
- SIFT matching
- Bundle adjustment
Multi-view 3D reconstruction – Image segmentation

Example: 2D segmentation with mean shift and background histogram matching

Original image

Background removed

Resulted silhouettes
Multi-view 3D reconstruction – Volume reconstruction

Cookie stencil/cutter

Visual Hull

cannot recover concave surfaces

Patch-based Multi View Stereo

needs good texture variations

Image processing for Accelerated Phenomics
Multi-view 3D reconstruction – 3D reconstruction

Commercial 3DSOM, visual hull based,
http://3dsom.com/

Image processing for Accelerated Phenomics
Multi-view 3D reconstruction – 3D reconstruction

Hull (visual hull based) provided by Changming Sun, 
not yet EVC (Embedded Voxel Colouring)

500x500x500 cube

Image processing for Accelerated Phenomics
Multi-view 3D reconstruction – 3D reconstruction

Open-source Patched-based Multi View Stereo (PMVS),
http://grail.cs.washington.edu/software/pmvs/

3D point cloud
(438,503 points)

High accuracy but needs good texture variations and additional meshing step
Multi-view 3D reconstruction – 3D reconstruction

Open-source Patched-based Multi View Stereo (PMVS),
http://grail.cs.washington.edu/software/pmvs/

3D point cloud
(1,093,823 points)
Image processing for Accelerated Phenon
Multi-view 3D reconstruction

**High performance consideration:**

- 3DSOM: single threaded, GUI interface package
- Hull: single threaded (can be parallelized), memory intensive
- Patched-based Multi View Stereo by *multi view clustering*:
  - Single threaded by itself
  - **But multi views can be clustered**
  - Parts of point cloud reconstructed independently
  - Point cloud parts merged at the end
3D Segmentation and Analysis


Image processing for Accelerated Phenomics
Conclusion and future plan

**What have been done**

- Setting up a working camera calibration procedure
- Investigating different 3D reconstruction techniques
- Analysing some different cotton plants

**What need to be done**

- Testing EVC
- Meshing 3D point cloud
- And/or 3D point cloud analysis (with PCL library, [http://pointclouds.org/](http://pointclouds.org/))
- Testing with more complex plants
- Testing with insects
Thank You

Contact CSIRO

Phone  1300 363 400
       +61 3 9545 2176

Email  enquiries@csiro.au

Web   www.csiro.au

CMIS/Quantitative Imaging

Name  Chuong Nguyen
Title  COE Postdoctoral Fellow
Phone +61 2 6216 7041
Email  chuong.nguyen@csiro.au
Web   www.cmis.csiro.au/iap

Paul Jackway, Ron Li, Changming Sun and David Lovell of CSIRO Mathematics, Informatics & Statistics
Xavier Sirault, Scott Berry and Robert Furbank of CSIRO Plant Industry, The High Resolution Plant Phenomics Centre
Anthony Paproki and Jurgen Fripp of CSIRO ICT, The Australian e-Health Research Centre
John La Salle of CSIRO Ecosystem Sciences
Multi-view data acquisition for Insects

Source: Lamprecht (2010) Insect Imaging System, CMIS

Image processing for Accelerated Phenomics
High performance consideration:

- 3DSOM: single threaded, GUI interface package
- Visual Hull: single threaded, memory intensive
- Patched-based Multi View Stereo by *Clustered Multi View Stereo*:
  - Single threaded by itself
  - But point cloud reconstruction highly independent
  - Independent reconstructions of different parts of point cloud
  - Point cloud parts merged at the end

- Bundler for auto calibration:
  - SIFT detection in individual images highly independent, GPUs accelerated (SiftGPU)
  - SIFT feature matching single threaded
  - Bundle adjustment can be multi threaded (Multicore Bundle Adjustment)
Multi-view 3D reconstruction – 3D reconstruction


3D point cloud (438,503 points)  3D voxelisation  3D iso-surface

Image processing for Accelerated Phenomics
3D Segmentation and Analysis


Image processing for Accelerated Phenomics