

pixeltraq

CAMERA CALIBRATION STATION SUMMARY

quartus



QUARTUS' PIXELTRAQ CAMERA CALIBRATION ARCHITECTURE

- Quartus' patent-pending camera calibration architecture is configurable for a wide variety of camera systems including:
 - Multi-camera arrays
 - Wide Field of View (FOV > 180°) cameras
 - Shallow Depth of Field cameras
 - Long working distances (up to 3m)
 - Can re-conjugate to infinity as needed
 - Multiple chart designs and configurable illumination
- Trio of software tools for pose generation, automated capture, and post-processing of composite “Supercharts”
- Industry-leading traceability of captured object points and integrated solver for most common camera models



Calibration Service Outputs Include:

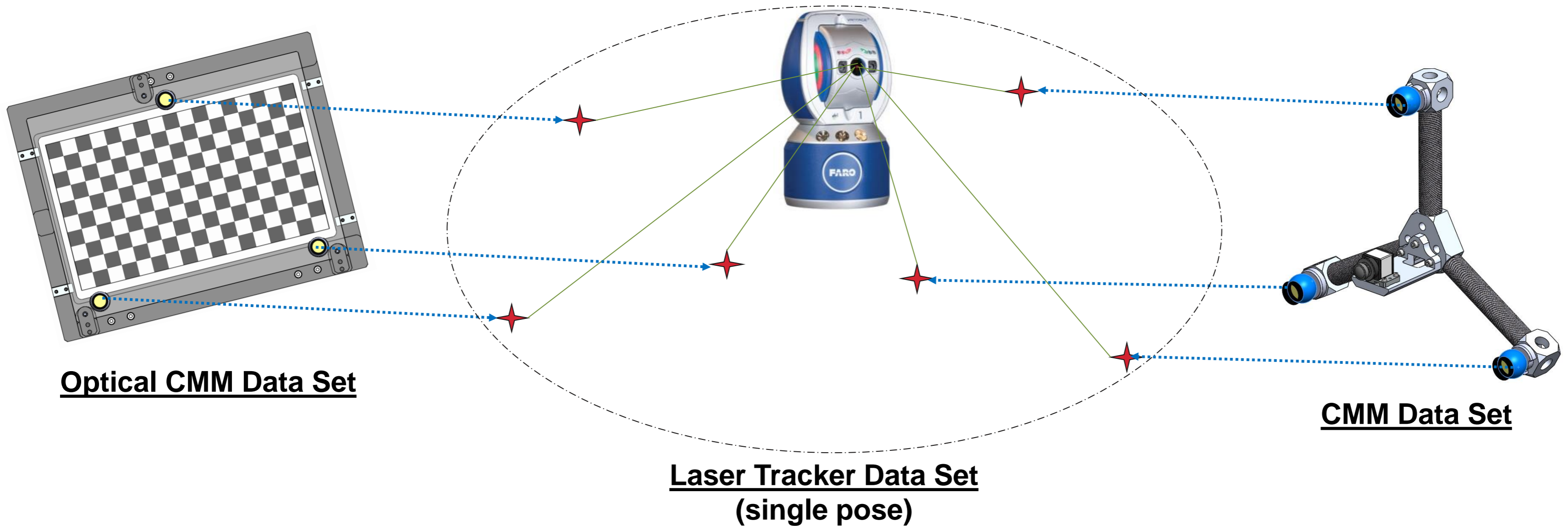
- Intrinsic Calibration Parameters:
 - Principal Point X, Y
 - EFL X,Y
 - Distortion Coefficients
- Volumetric SFR (Through Focus MTF, Depth of Focus)
- 6DOF Pupil Position & Pose (Relative to mounting fiducials)
- Residual and model reprojection plots
- Model quality Figures of Merit (FOMs)

Camera Calibration Applications Include:

- Computer Vision Inspection
- Vision Assisted Robotics
- Automated Quality Control
- Geometric Measurement (In plane, Angular, Depth)
- Virtual Image Distance Measurement
- Camera Array Epipolar Error

TRACEABILITY AND UNCERTAINTY IN CAMERA CALIBRATION

- One-time OMM/CMM inspections of chart and camera mount are required
- A calibrated laser-tracker in the loop provides traceable inspection of chart relative to camera for any programmed pose
- Each point correspondence (image/object space) is traceable with a known maximum permissible error



STANDARD CALIBRATION WORKFLOW & SOFTWARE TOOLS

Pre-Processor

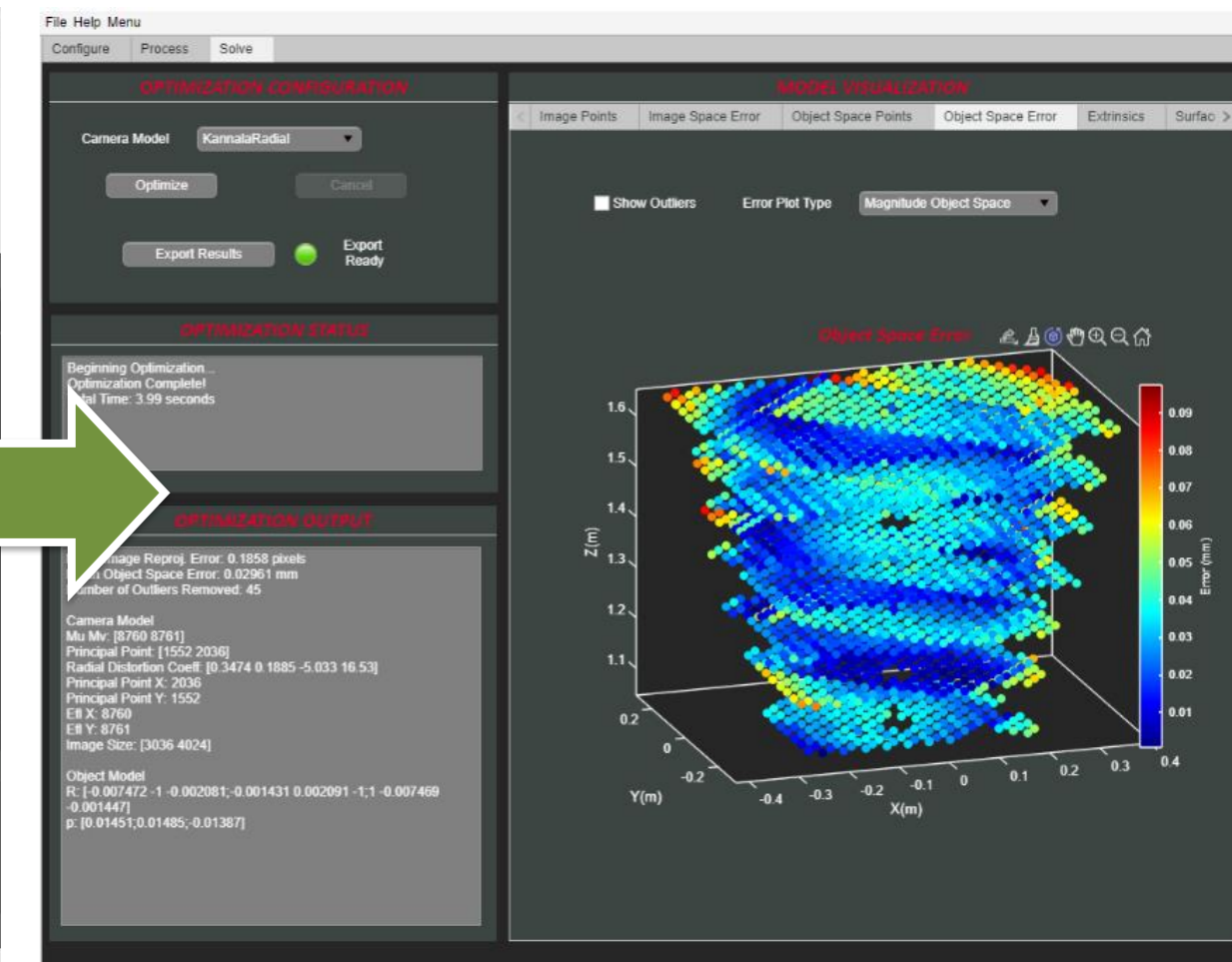
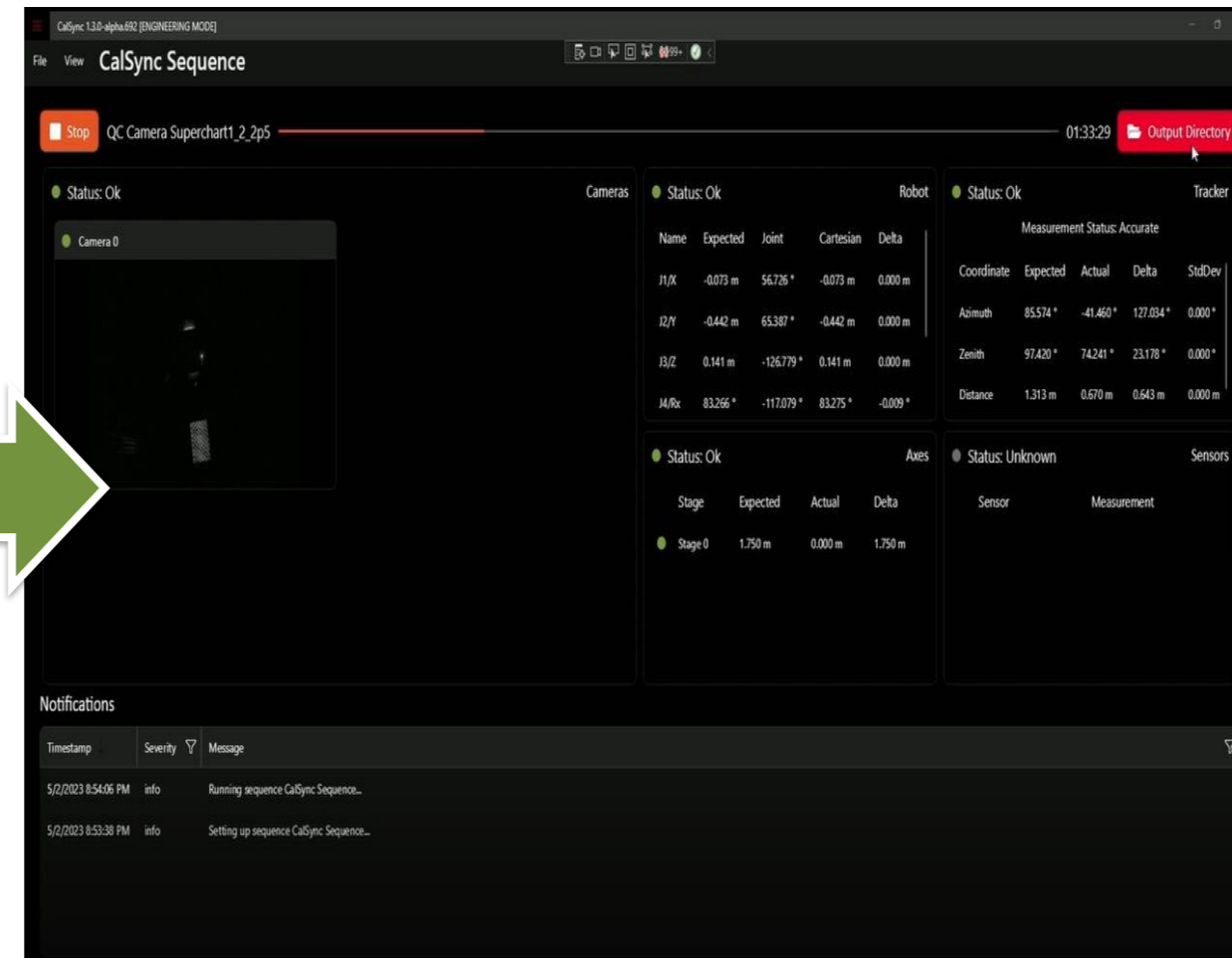
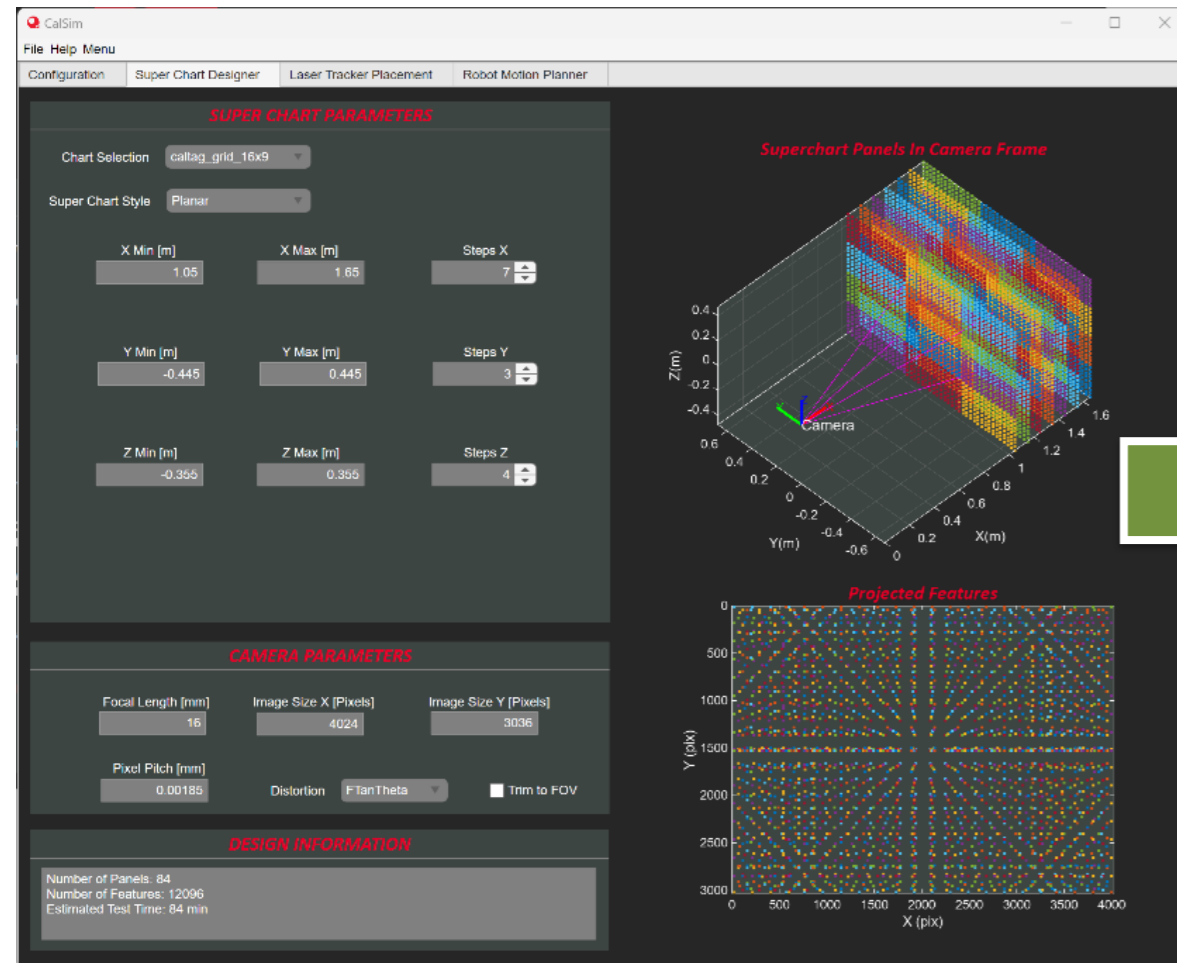
- FOV and depth coverage
- Target density
- Trajectory simulation
- Laser Tracker programming

Sequencer

- Camera capture w/ live view
- Load calibration profiles
- Motion control
- Laser tracker control

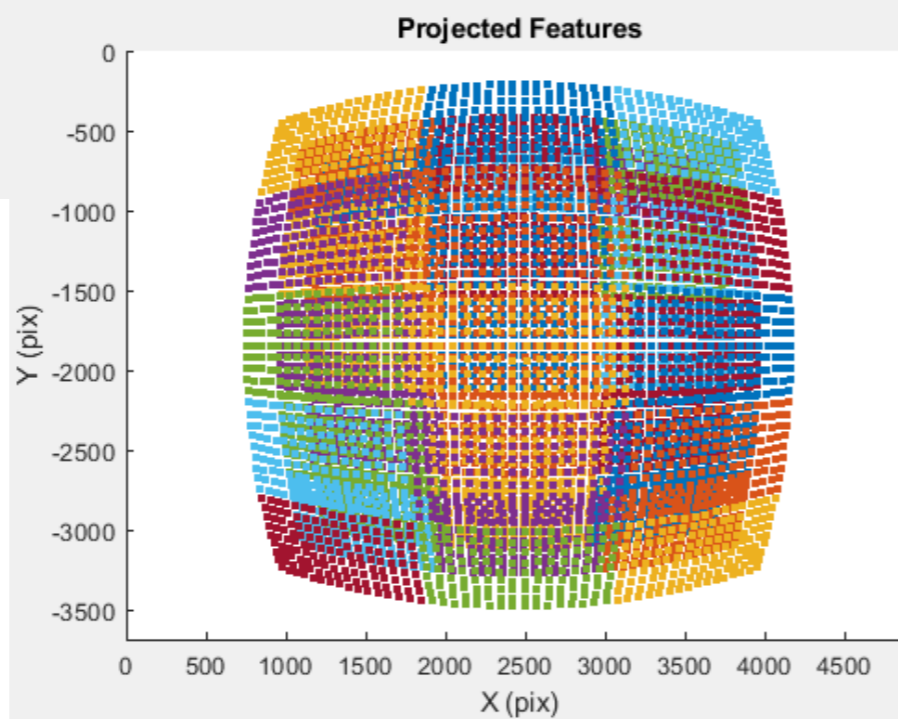
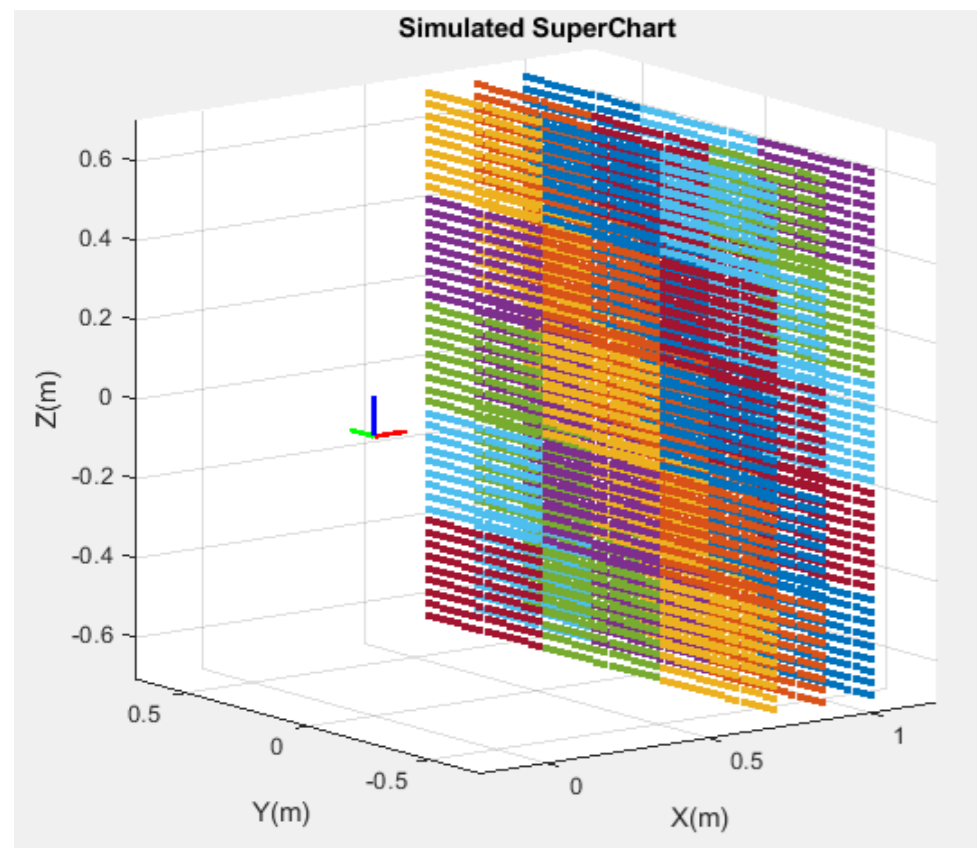
Post-Processor

- Parametric model optimization
- Image space error visualization
- Object space error visualization
- Audit data testing



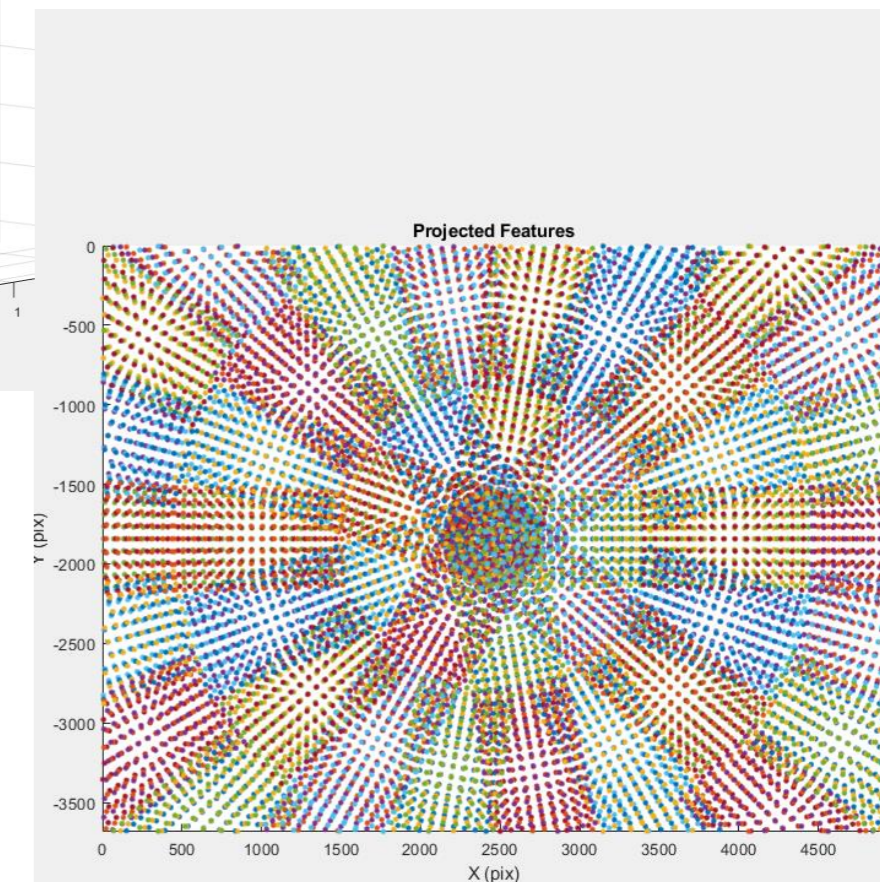
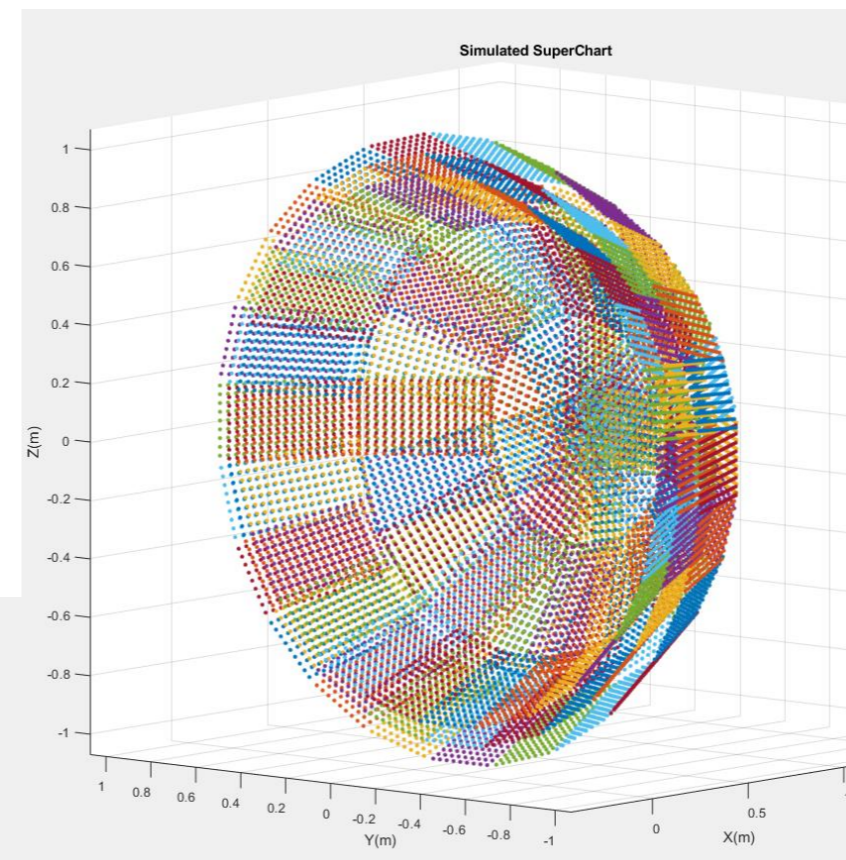
CONFIGURABLE “SUPERCHART” GEOMETRY

Planar Charts



6480 Chart features in Image Frame

Hemispherical Charts



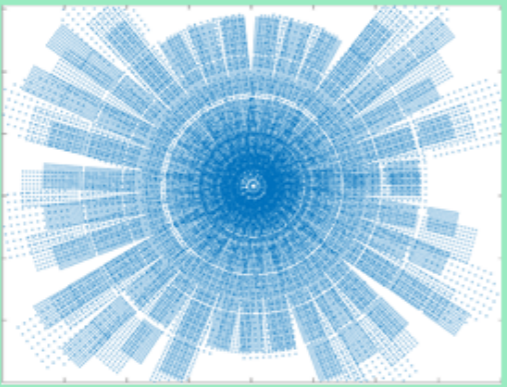
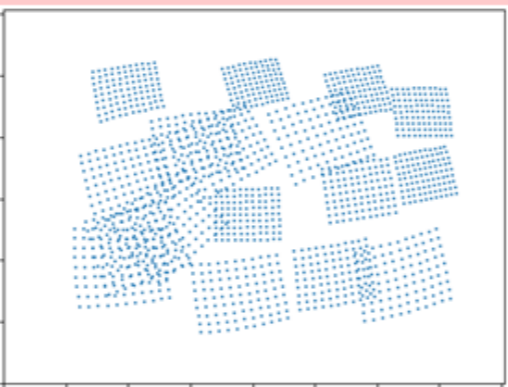
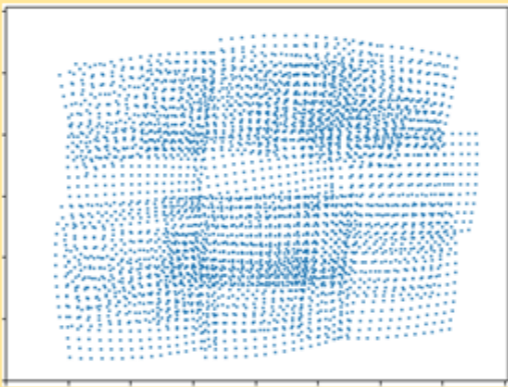
15230 Chart features in Image Frame

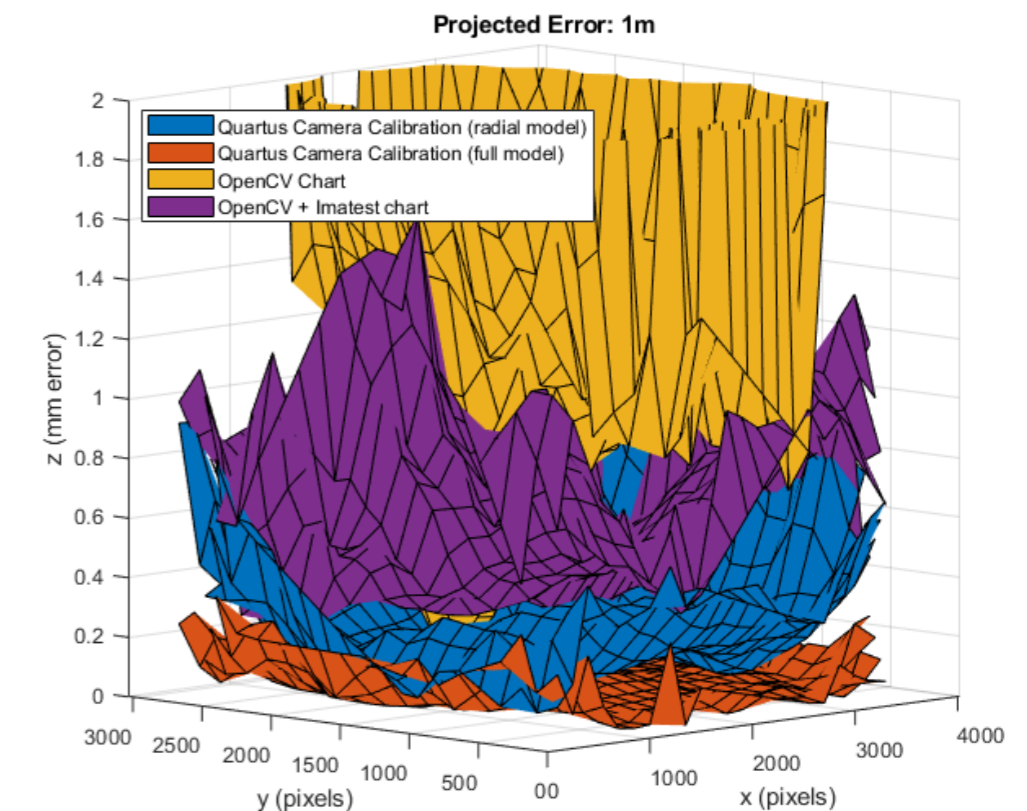
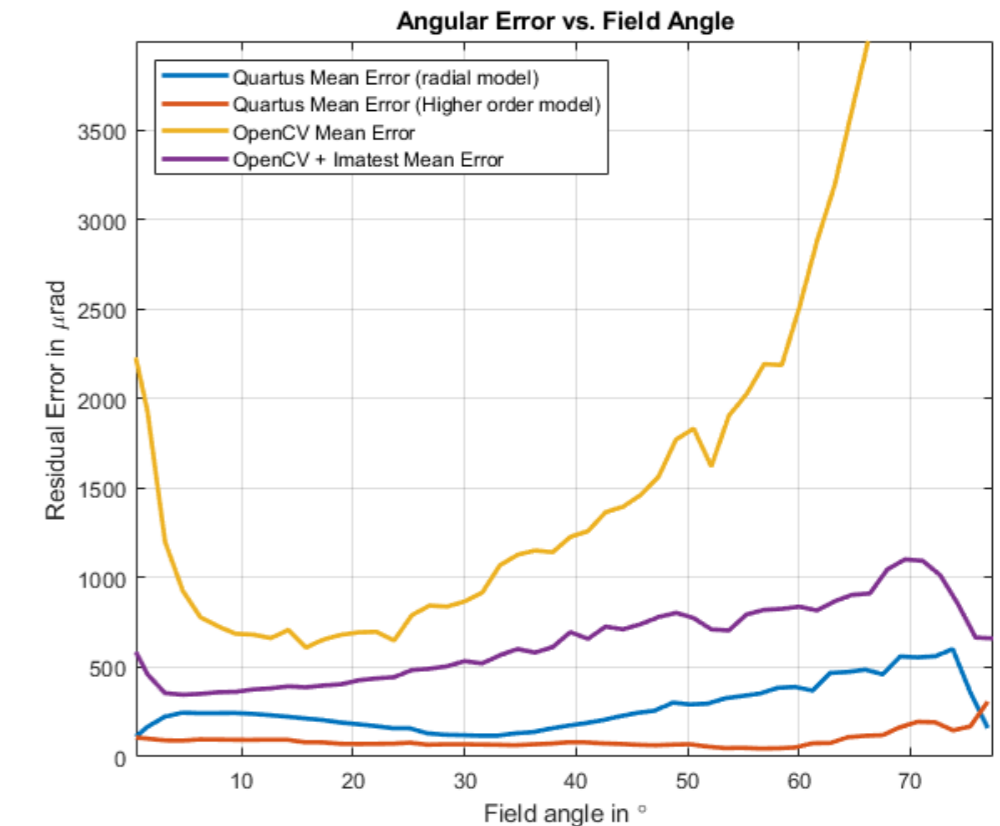
PIXELTRAQ CASE STUDY - WIDE FOV INDUSTRIAL CAMERA

Camera Specs:

- Sensor: Basler acA4024-29um
- Lens Focal Length: 2.8mm
- FOV: 156°



	pixeltraq	OpenCV	OpenCV + High Quality Chart
Features	>38,000	1683	4114
Traceable Extrinsic	✓	✗	✗
FOV Coverage			
Data Collection	Automated	Manual	Manual
Mean Reproj. Error	Calibrated: 0.36 pixels Audit Set: 0.37 pixels	Calibrated: 0.30 pixels Audit Set: 2.1 pixels	Calibrated: 0.28 pixels Audit Set: 0.91 pixels
Object Space Reproj. Error	0.48mm	2.31mm*	1.16mm*



PIXELTRAQ CASE STUDY - WIDE FOV BINOCULAR ARRAY

End-Effector Specs:

- Cameras: M2020, 1/1.8" Monochrome, Dalsa Genie Nano GigE PoE
- Lens: 3.5mm, f/2.8 Cr Series Fixed Focal Length Lens
- FOV: 75° (V) x 100° (H)
- Focus Distance: 1m
- Binocular Camera Spacing: 100 mm



DEPTH HEATMAP OUTPUT



POINT CLOUD OUTPUT (XYZ)



IMAGE PROCESSING WORKFLOW

CAMERA CALIBRATION

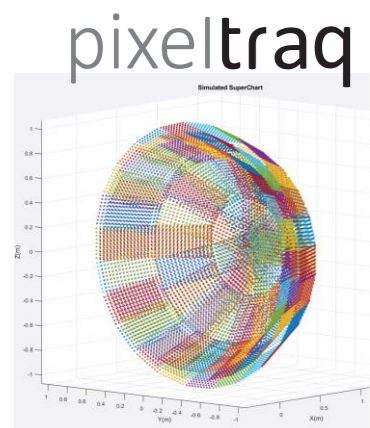


IMAGE UNDISTORTION

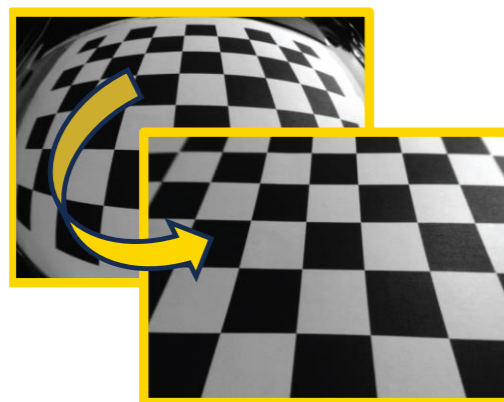
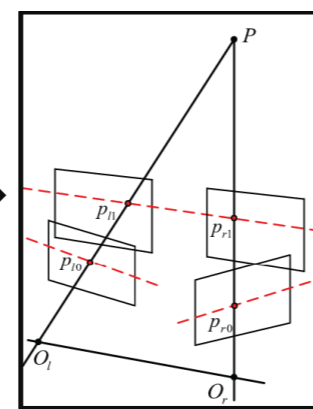
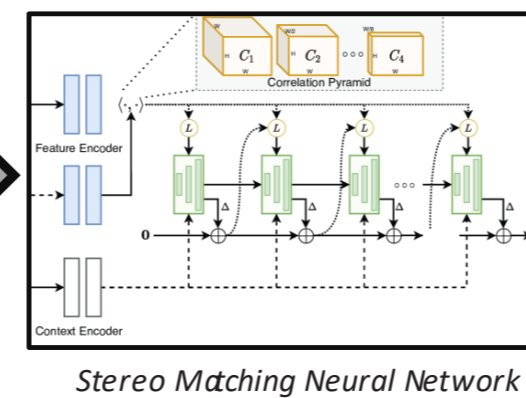


IMAGE RECTIFICATION



DISPARITY CALCULATION



PIXELTRAQ CASE STUDY – VOLUMETRIC SFR

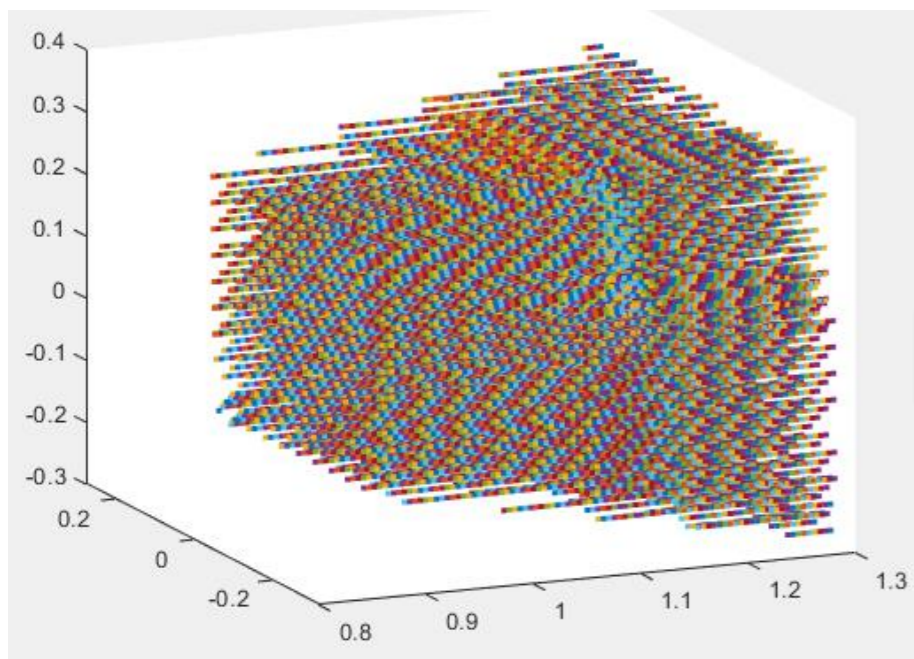
Camera Specs:

- Camera: IOI Victorem 62G41-CX
- Sensor: Gpixel GMAX0505
- Lens Focal Length: 50 mm
- FOV: 15° (V) x 15° (H)
- Focus Distance: 1.1m

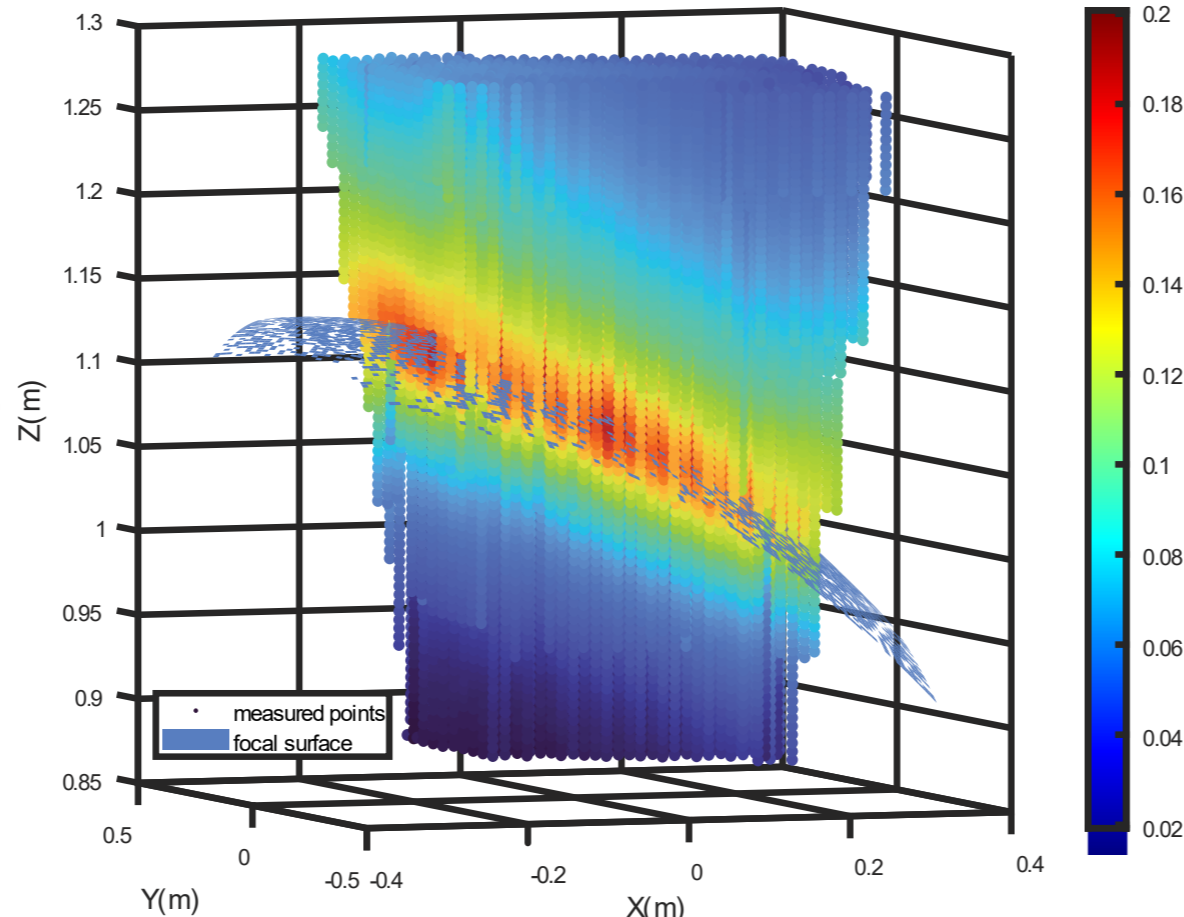


- By collecting a dense data in PixelTraq, shallow Depth of Focus (DOF) imagers can have their entire field characterized for resolving capability (contrast)
- The circular features on PixelTraq charts are used to extract circular Spatial Frequency Response (SFR) such that contrast can be evaluation for a wide range of frequencies, MTF values, and directions (sagittal, tangential, XY)
- This volumetric data is critical in evaluating Depth of Focus as well as impacts from real-world alignment errors such as sensor tilt relative to optical axis
- The data set can additional be processed for conventional thru-focus MTF plots

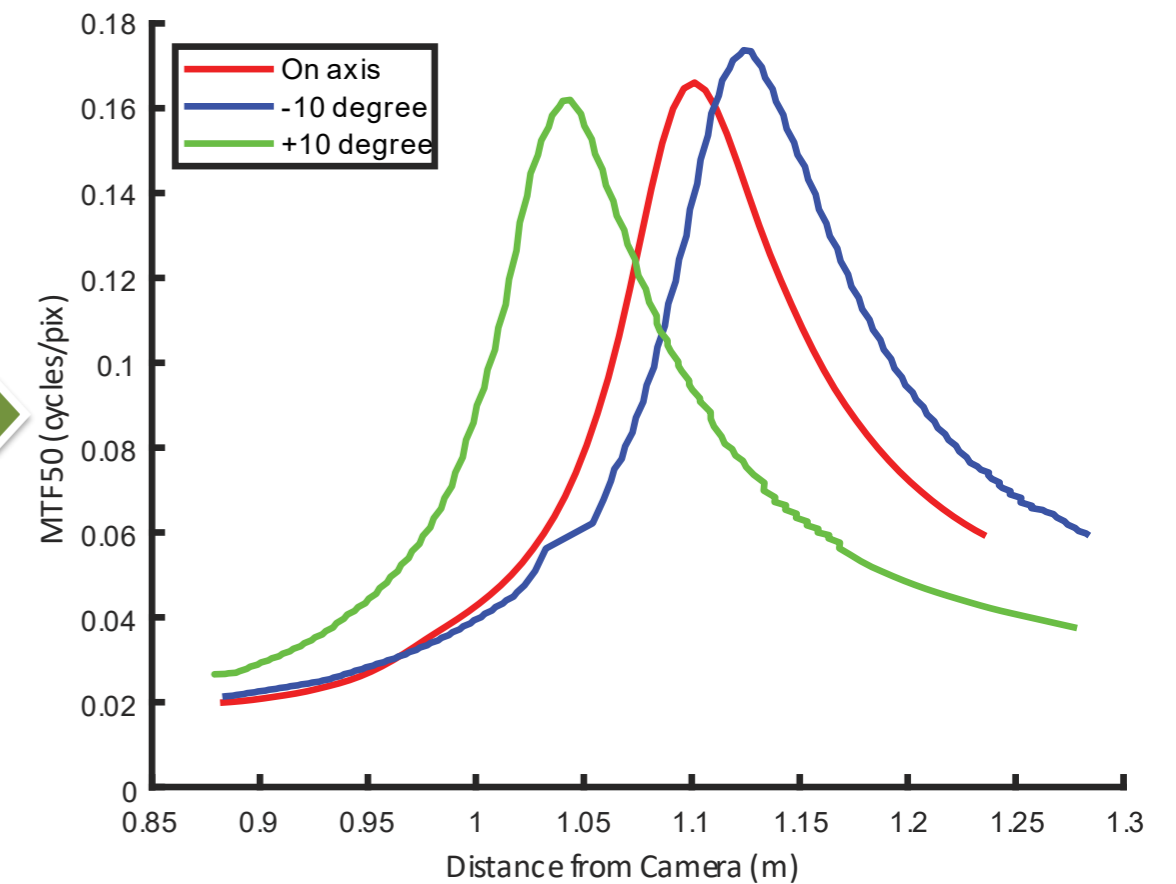
HD Calibration Data Set



Volumetric MTF and Best Focal Surface



MTF50 vs Distance



CAMERA CALIBRATION ENGAGEMENT MODELS

- Customer camera / instrument calibration on Quartus' stations
 - Setup fee + hourly rate
- Fixed price machine vision camera modules
 - Quartus assists in selection of camera and lens, provides assembly and calibration services
- Camera Calibration Station sold as a complete fixture
 - Standard configurations or customized per each installation:
 - Robot payload and reach (UR5/UR10e/UR30)
 - Chart mount (single fixed vs. indexing turret)
 - Linear travel range for chart mount

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 FLEXIBLE CAMERA CALIBRATION

CAPABILITIES

- PixelTraq's system architecture allows creation of precision calibration targets that meet your field of view, working distance, area coverage, and extrinsic datum needs
- Complete geometric (intrinsic and extrinsic) parametric calibration
- On-axis and volumetric characterization of focus via spatial frequency response
- Options for calibration wavelength as well as multi-wavelength calibration for testing chromatic variations
- Scalable from telephoto to super wide field of view configurations
- Bring your own camera; we can support all common camera brands as well as custom cameras
- Export to your preferred model file format

APPLICATIONS

- Factory Automation Vision Systems
- Aerospace Vision Systems
- Autonomous Driving Sensor Fusion
- Visual Servo Systems
- IOT Cameras
- Industrial Metrology Systems
- Medical Imaging
- Machine Vision Research
- 3D Scanning
- Remote Sensing
- Sensor Validation
- IMU Correlation

CASE STUDY SUMMARY

- CalSync provides a more robust and accurate camera calibration for real world use
- Traceable audit data sets reveal that low reprojection errors in calibration data is not a guarantee for low error once installed
- CalSync is the only calibration approach that provides traceable extrinsics for an accurate estimate of pupil pose with respect to camera datums

Case Study Camera Specs:

- Sensor: Basler acA4024-29um

The Quartus PixelTraq process* offers highly accurate, traceable camera calibrations tailored to your application's needs. Available as a service for customer camera calibration or as the foundation for a turnkey vision system.

Configurable calibration scenes include multi-layered planar, curved and application specific high density composite charts

Object space reprojection error analysis included in the calibration for real-world accuracy predictions and quality assurance

When full FOV calibration accuracy, traceable datums, or target working distances are important, PixelTraq can help you meet your requirements.

*PATENT PENDING

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CAMERA / INSTRUMENT INTAKE REQUIREMENTS

- Camera Details:
 - Sensor size, pixel size
 - Software interface – USB, gigE, CXP, CameraLink, etc
 - Mechanical interface – CAD file or ICD with key datum callouts
 - Nominal focal length
- Calibration Parameters:
 - Wavelengths (white light, monochromatic, multiple, etc)
 - Chart design (Quartus chart or customer specific)
 - Nominal working distance
 - Field of View (FOV) coverage
- Calibration Outputs:
 - Camera model desired (Kannala, Brown Conrady, Radial/Full, Best fit etc.)
 - Extrinsic calibration coordinate frame
 - Pass/Fail limits required
 - MTF, reprojection error, object space error, etc

