

Initial Calibration of a High Resolution Digital Camera for Accelerator Alignment



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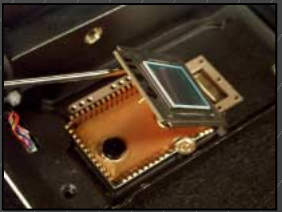


Project Goal
Determination and assessment of the camera calibration parameters.

Ultimate Goal
Fast, accurate, and reliable alignment using high-resolution digital photogrammetry.

Equipment

- Camera Body: Nikon N90s
- Camera Back: Kodak DCS460m
- CCD Size: 3060 pixels by 2036 pixels
27.6 mm by 18.4 mm
- Nikkor Lens: 24 mm f2.8D
- Storage: PCMCIA Hard Disk Drive
170 MB, 340 MB
- Flash: Nikon SB-26



Procedure

Six positions (as shown) were chosen for optimal geometric coverage and adequate redundancy. They were "permanently" marked so that the geometry of the survey could be kept constant. Testing the impact of the geometry is easier than isolating camera-specific factors.

Testing

- 1) Repeatability
 - short term (< 1 hour)
 - long term (> 1 week)
- 2) Handling Effects
 - camera manipulation
 - lens removal
- 3) Orientation
 - 0°, 90°, 180°, 270° and 360° roll

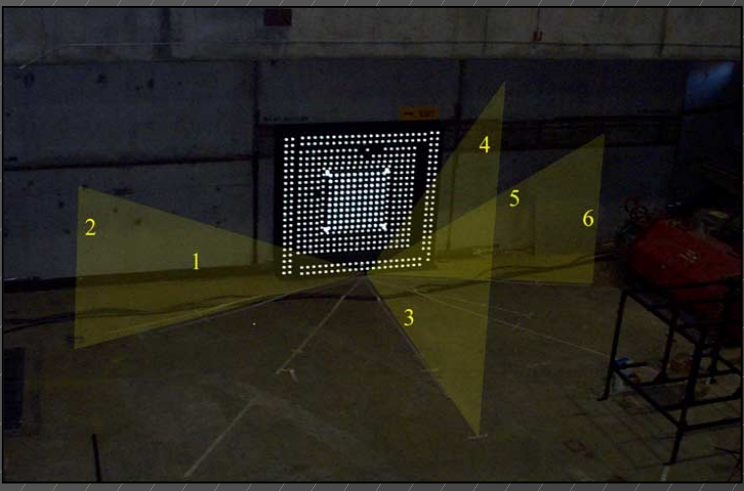


Target Description

- Shape: 9/16" diameter circle
- Material: 3M Scotchlite High Gain Sheeting

Target Layout

- Initial: 100 targets on a 100 x 100 cm grid
- Extended: 550 targets on a 275 x 235 cm grid with 50 cm maximum depth



Analysis and Results

Software: • Australis v1.0, University of Melbourne
• Pattern Matching / Lego Bundle, SLAC

Overall results based on identical minimal constraints:

Calibration Parameter	Value	Repeatability
Focal Length	f 24.330 mm	0.030 mm
Principal Point Offset	x _p -0.200 mm	0.050 mm
	y _p -0.100 mm	0.050 mm
Radial Symmetric Distortion	K ₁ 1.65 × 10 ⁻⁴	5 × 10 ⁻⁶
	K ₂ -2.9 × 10 ⁻⁷	5 × 10 ⁻⁸
	K ₃ -2 × 10 ⁻¹⁰	10 ⁻¹⁰
Decentering Distortion	P ₁ 3.5 × 10 ⁻⁶	N/A
	P ₂ -1.4 × 10 ⁻⁵	N/A
Correction for Affinity and Non-Orthogonality	B ₁ -1.5 × 10 ⁻³	5 × 10 ⁻⁴
	B ₂ 0.5 × 10 ⁻³	5 × 10 ⁻⁴

Conclusions

These tests have shown that fast and accurate alignment of accelerator components is possible using the non-metric Kodak DCS 460m digital camera shortly after being calibrated. The two software packages provided comparable solutions. Short term repeatability was achieved. The effect of orientation changes, camera jarring and the lack of long term repeatability, all point toward an internal displacement of the CCD chip.

Examination of the CCD housing and careful manipulation of the chip itself indicated that indeed it moves. Being a non-metric camera that would normally sustain jarring, the spring mechanism is reasonable for non-photogrammetric use. Two clamps were designed to hold the chip stable. Further testing of this new chip configuration is planned.