SLAC-WP-053

Initial Calibration of a High Resolution Digital Camera for Accelerator Alignment

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Ultimate Goal

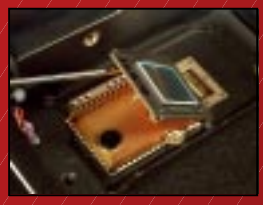
Fast, accurate, and reliable alignment using high-resolution digital photogrammetry.

Project Goal

Determination and assessment of the camera calibration parameters.

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
   - 0º, 90º, 180º, 270º and 360º 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.