



# Biometric Standards, Performance, and Assurance Laboratory



DEPARTMENT OF INDUSTRIAL TECHNOLOGY  
PURDUE UNIVERSITY

## The Effects of Varying Illumination Levels on FRS Algorithm Performance

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### Abstract

This study evaluated the performance of a commercially available face recognition algorithm for the verification of an individual's identity pertaining to three enrollment illumination levels. Existing face recognition technology from still or video sources is becoming a practical tool for law enforcement, security, and counter-terrorist applications despite the limitations of the current technology.

This evaluation examined the influence of variations in illumination levels on the performance of a face recognition algorithm, specifically testing the significance between verification attempts and enrollment conditions with respect to factors of age, gender, ethnicity, facial characteristics, and facial obstructions.

The failure to enroll (FTE) rates from the low illuminance (7-12 lux), medium illuminance (407 - 412 lux) and high illuminance (800 - 815 lux) enrollments were 6.25%, 3.22%, and 1.09% respectively, while the failure to acquire (FTA) rates were 0.92%, 0.65%, and 0.00%.

The results of the evaluation showed that for low and medium illuminance enrollments there was a statistically significant difference between verification attempts made at low, medium, and high illuminance at  $\alpha = 0.01$ . However for the high illuminance enrollment, there was no statistically significant difference between verification attempts made at low, medium or high illuminance at  $\alpha = 0.01$ .

### Experimental Setup

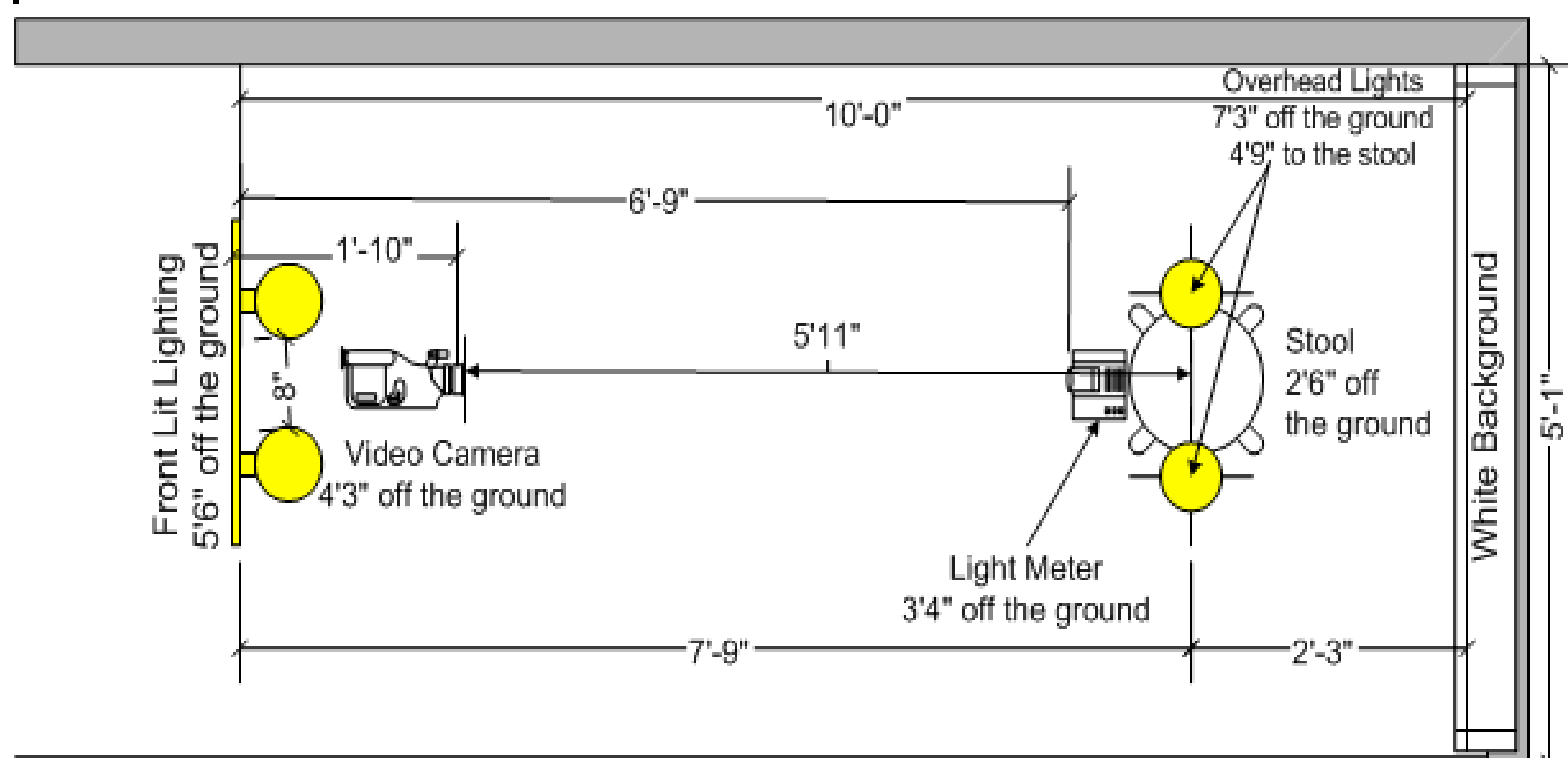
This evaluation took place in Biometric Standards, Performance and Assurance Laboratory in the School of Technology at Purdue University. The experimental design used a setup that was used was similar to the 2002 Face Recognition at a Chokepoint Scenario Evaluation sponsored by the Department of Defense Technology Development Program Office.

#### System

The system evaluated was defined as scenario evaluation that was:

- Cooperative
- Overt
- Unhabituated (although on subsequent visits participants became habituated)
- Attended
- Closed

#### Experimental Area



### Illumination

This study evaluated the performance of a commercially available facial recognition algorithm in three illumination levels.

- The first light level, 7 -12 illuminance (lux) referred to as enrollment condition 1, was determined by logging 60 minutes of data from a local campus restaurant.
- The second light level, 800 - 815 illuminance (lux) referred to as enrollment condition 3, was determined by logging 60 minutes of data from the Industrial Technology office.
- The third light level, 407 - 415 illuminance (lux), referred to as enrollment condition 2, was determined by taking the mean of the other two light levels.

To alter the light levels, the front and overhead lamps (shown above in yellow) were controlled by a dimmer switch. The three illumination levels were then monitored through a broad range LUX/FC light meter connected to a PC. The light meter readings were displayed on a computer monitor and recorded with data logging software so each attempt and the corresponding light level could be analyzed for consistency and repeatability.

### Results

The evaluation composed of two phases.

- 1) The first phase consisted of 3 separate enrollment instances in 3 separate databases for each separate scenario: low, medium and high.
- 2) The second phase consisted of 3 verification attempts in each scenario for each instance. A total of 27 verification attempts were made each visit.

Data was collected from participants on three separate visits over a period of four weeks. Enrollment was completed during the first visit. Verification was conducted during all three visits for a total of 81 attempts for three visits. A total of 2,412 images were collected during this evaluation.

Two participants had problems during enrollment phase. One wore a hat, which when removed was able to enroll. Accordingly, there were 6 enrollment failures out of 96 attempts. Therefore, the overall failure to enroll (FTE) rate was 6.25%.

Enrollment Condition 1: Low Light Illuminance 7 - 12 lux				
	Light Level	FTE	FTA	Match %
Verification Attempts	Low Illuminance	6.25%	1.57%	89.62%
	Medium Illuminance	-	1.18%	57.40%
	High Illuminance	-	0.00%	58.70%

Enrollment Condition 2: Medium Light Illuminance 407 - 412 lux				
	Light Level	FTE	FTA	Match %
Verification Attempts	Low Illuminance	-	1.57%	73.88%
	Medium Illuminance	9.09%	0.39%	91.48%
	High Illuminance	-	0.00%	95.37%

Enrollment Condition 3: High Light Illuminance 800 - 815 lux				
	Light Level	FTE	FTA	Match %
Verification Attempts	Low Illuminance	-	0.00%	80.55%
	Medium Illuminance	-	0.00%	89.44%
	High Illuminance	3.22%	0.00%	94.25%

The statistical analysis revealed that at a high illumination enrollment, the illumination of the verification attempt was not significant, based on the three tested illumination levels. For the low and medium enrollment instances, the illumination used for the verification attempts was significant, which meant that enrollments using low and medium illumination, defined for this evaluation, are not good to use when your environmental lighting conditions are not constant for verification, specifically at 3 levels: low (7-12 lux), medium (407 - 412 lux), and high (800 - 815 lux).

### Conclusion

The results of this study show that there are still significant challenges with regard to illumination levels and face recognition especially at lower light levels, which is in line with other research that has been done. It was also interesting to note that at the high-illumination enrollment, there was no statistically significant difference in the verification rates between low-, medium-, and high- illumination attempts, meaning when lighting conditions are not constant for verification, the enrollment light level should be high, defined for this evaluation at 800 - 815 lux.

