Imaging System for Measurements of Beam Patterns

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Motivation

- Industries related to lighting such as indoor/outdoor illumination, automotive, avionics, and medical are regulated by global standards and recommendations.
- Ex: Automotive Industry must comply with UNECE(Europe), CMVSS(Canada) or FMVSS(USA), as well as attempt to follow recommendations from the SAE.
- Standards define permissible ranges and gradients for luminous intensity and colour at different test locations, under a number of measurement geometries and operating conditions.
- **Traditional method uses goniometer and spot detectors.** This method is referred to as the Goniometer Method.
- ***Goniometer Method is time-consuming,*** which creates a burden in production and QA test environments.

Objective

To obtain *more complete* beam pattern measurements with a 2-D imaging system, rather than a spot detector system, such that when compared to corresponding Goniometer Method measurements, the 2D imaging system:

- Is accurate to within 10%;
- Reduces measurement time by at least 90%.

Methods

- Imager Method uses 2-D imaging colorimeter and diffusely reflecting screen.
- Imager placed adjacent to test source and focused on image formed at the screen, as shown in Figure 1.
- The system is calibrated for tilt angle of the camera using perspective transform algorithm[1].
- The screen-imager system is calibrated for luminous intensity using a NIST-traceable calibration source.

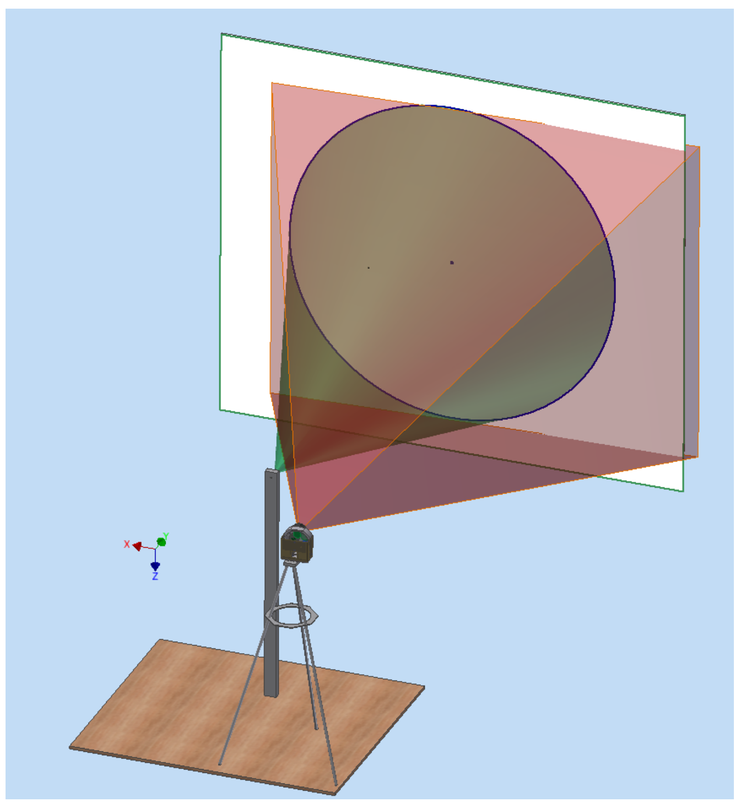

Figure 1: The setup for the Imager Method for measurements of beam patterns.

Experiment

Goniometer Method

1. Test light source set up on goniometer at a distance of 100 feet from spot detectors (Figure 2).
2. Luminous intensity measurements taken with source tilted at angles of 0°, 5°, 10° in horizontal and vertical directions.

Figure 2: LEFT: light source placed onto the goniometer; RIGHT: spot detectors measure the luminous intensity at each goniometer position.

Imager Method

Imager: WP690 9MP colorimeter with Nikon Nikkor 24mm lens.

1. White, diffuse screen set up normal to the optical axis, 100 feet from the test light source.
2. Imager set up off axis by 15 feet, tilted such that the entire screen covers the field of view.

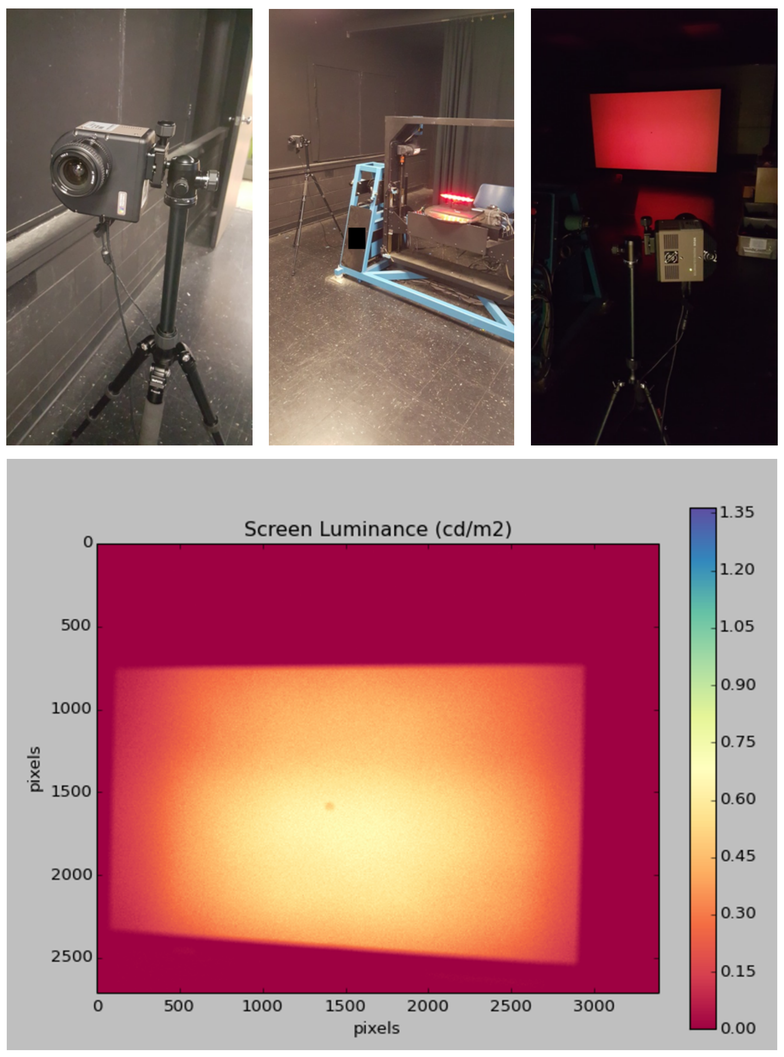

Figure 3: TOP-LEFT: imager used for the beam pattern measurement; TOP-CENTRE: light source used for the test; TOP-RIGHT: rear view showing projected image of source onto the screen. BOTTOM: Luminance image of the screen as seen by the imager.

Results

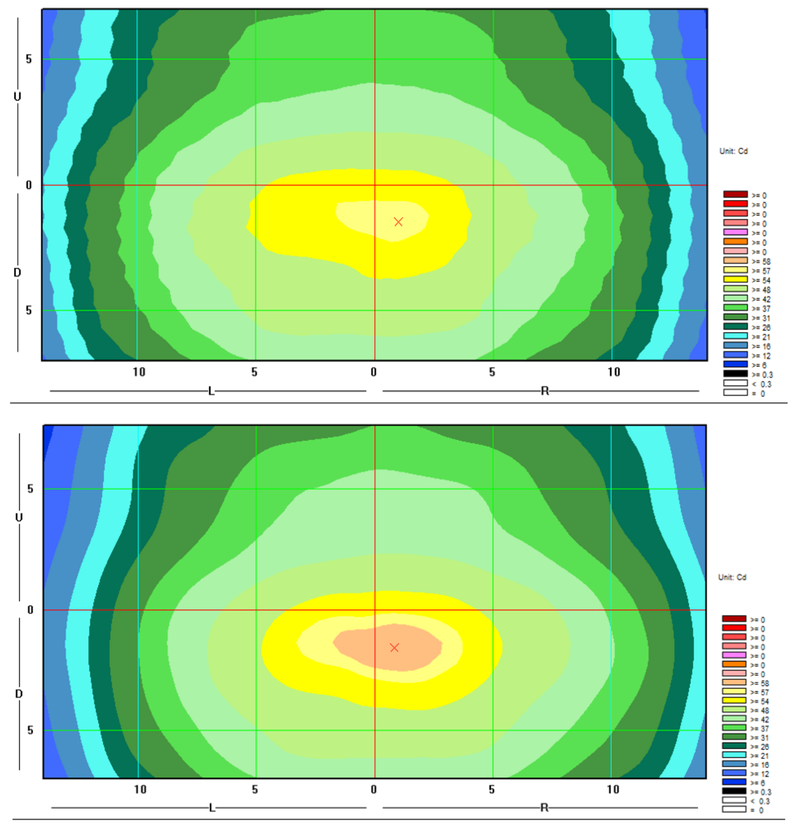

Figure 4: Luminous intensity distribution of the test lamp measured using the Goniometer Method (TOP), and Imager Method (BOTTOM).

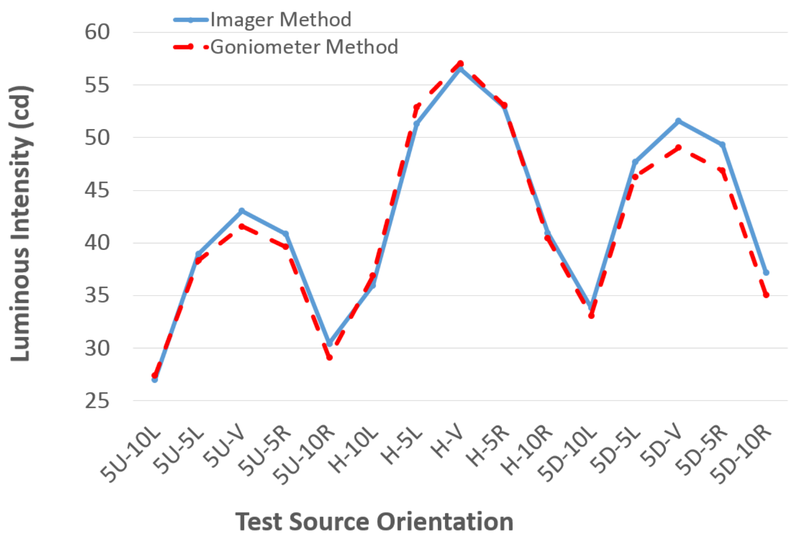

Figure 5: Beam pattern measurement comparison results. The vertical axis represents the luminous intensity measured by either the Imager Method(solid blue line) or Goniometer Method (dashed red line).

Conclusions

- The Imager Method consistently provided luminous intensity measurements that were within 6% of those obtained from the Goniometer Method.
- Imager Method measurement time was 30 seconds; Goniometer Method measurment time was 15 minutes.
- With adequate accuracy and 20-fold improvement in throughput, many production environments would benefit from this imaging system.
- More work will be done to test the effectiveness of this approach across different light sources, camera tilt-angles, and lens focal lengths.

References

[1] Richard Szeliski (2010). Computer Vision: Algorithms and Applications. Washington: Springer.

Acknowledgements

Photos and data are courtesy of a confidential collaborator.

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