P10541: Micro-gloss Measurement System

Project Review

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PROJECT DESCRIPTION

- Micro-goniophotometer
  - Micro-gloss measurement device

- Evaluate the gloss characteristics of a sample/surface by measuring both spatial resolution (micro-) and angular resolution (gonio-) in order to correlate meaningfully visual perceptions of gloss and also the underlying causes of gloss.
Market:

- Printing companies
- Chemical engineers
- Paper manufacturers
- Imaging scientists

Key High Level Customer needs:

- All-in-one device – assemble once and done
- Easy sample loading – no tape required
- Eliminate sources of error from previous device
  - Camera normal measurement, polarizing lens rotation, working distance, instrumentation angle
- Small size and weight
- Measurement consistency within 5% (old device was within 10%)
Primary Engineering Specifications:

- 22 x 14 x 9 inches
- Under 30 lbs.
- Runs on wall power
- Only one operator required
- Can measure gloss anywhere on an 8.5x11in sheet of paper
- Can use any of the three primary light source colors for measurement
CONCEPT DESIGN

Linear Fiber Optics Array
Sample holder
Camera
Polarizer
LED Block
Linear Fiber Optics Array
P10541 System Wiring Diagram

Diagram showing connections between 110VAC, DC Power Supply, Relay, 700mA Current Driver, RED, BLUE, GREEN Light Source, 3V Regulator, and ON/OFF Indication LED.
GUI

Images open
In ImageJ

Entered
parameters

Results

- Bright Image:
- Dark Image:
- Reference Reflectance: 0.45
- Reference Area: 1
  Enter 1 if measuring a reference sample
- F-step Measurement:
- Field of View:
- Auto Baseline

Minimum angle: [ ] Maximum angle: [ ]

[Analyze]

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<th>whall</th>
<th>w10</th>
<th>h</th>
<th>rho</th>
<th>granularity</th>
<th>aperture</th>
<th>...</th>
<th>sigma</th>
<th>skewness</th>
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[Save BRDF] [Save result vector]
Final Product
Final Product
SYSTEM ARCHITECTURE

1. Load Sample
   - Choose Light Source Color
     - Camera Adjustments
   - ADC
2. Capture Bright Image
   - Computer Display
3. Capture dark Image (Polarized)
4. Results (GUI Display)
5. Software Analysis
   - Java Plugin in ImageJ

Power Switch
- Power System
  - ~120 VAC
SYSTEM TESTING RESULTS

• Goals met
  • Device consistency goal (+/- 5% when measuring exact same sample) met when sample is not moved and camera settings are not changed
  • Program outputs match MathCAD program outputs for same input
  • Samples are much easier to load and measure
    • No strings needed
    • No tape needed
  • Device is self-contained as one unit
  • Smaller than last team’s device
• Goals not met
  • Device is inconsistent when zooming in or rotating sample around drum
  • Cylinder not precisely aligned
  • Specific size requirement not met
**Test 1**
Repeating captures of the same sample without re-mounting the sample, zooming, or changing the f-stop

\[
\text{FOV} = 11.509375\text{mm}, \quad \text{F-stop value} = 232
\]

Consistently within error range (+/-5% of desired value of 1)
Test 2
Repeating captures of the same sample without zooming or changing the f-stop, but re-mounting the sample

FOV = 11.509375mm, F-stop value = 232

Well outside error range (+/-5%), mean value of 1.149 which is 15% higher than desired value of 1
Test 3
Repeating captures of the same sample without changing the f-stop, or re-mounting the sample, but zoomed in

\[ \text{FOV} = 5.85390625\text{mm}, \text{F-stop value} = 232 \]

Consistently within error range (+/-5% of desired value of 1)
Test 4
Repeating captures of the same sample without changing the f-stop, or re-mounting the sample, but zoomed in, using Test 1’s reference area.

FOV = 5.85390625mm, F-stop value = 232

Consistently double desired value (mean 2.004) when FOV half of FOV of reference sample

Zoom 2x → get doubled area??
Problems

• When zooming on the same sample, measured areas change relative to change in field of view. Area should remain the same at any zoom level (could be a math problem).
• When re-mounting the same sample and running calculations, the values are running on the high side by approximately 15%.
• Reflection is also skewed (rotated) so that it is not perfectly vertical in the captured image (could be alignment problems, could also be that the sample is not held tightly to the cylinder).
• The shift causes errors in the “Auto baseline” calculation (not often used anyway).
• Re-mounting a sample also sometimes causes differences in data besides a shift.
VERIFICATION TESTING

Temperature Test

• Device Left on for 21 hours:
  - Ambient room temp: 75 deg F
  - LED block: 75 deg F
  - Power supply: 90 deg F
  - Device temp: 76 deg F
  - LED back surface: 173 deg F
  - Camera: 92 deg F

Light Test

• To determine if there is external light entering the device

Vibration Test

• To determine the effect of vibration on the results
Objective Project Evaluation

- Slightly over on case dimensions (supposed to be 20x14x9, actually 24.25x20.75x8.5)
- Alignment causes errors in analysis
- Mathematical theory error causes error when changing field of view setting from the one used for the reference sample
- Many sources of error were removed (polarizing lens, working distance, instrumentation angle)
- Many inputs were removed from the ImageJ plugin (camera normal, working distance, instrumentation angle, cylinder diameter)
- Sample loading is now less error-prone
Future Improvements

• Miniaturize the device by using a smaller camera and lens, using only spaces needed, using a different sample loading mechanism, changing the geometry

• Simplifying the device operation by:
  • Designing a self sensing mechanism for saturation adjustment
  • Using a controller to slide the polarizer
  • Automate the mechanism of determining the field of view
  • Integrate these processes in the Java code
Thank You