EVALUATING SMARTPHONE LIGHT METERS' EFFECTIVENESS

A COMPARISON BETWEEN INDUSTRY LIGHT METERS AND LIGHT METER APPS

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Official Industry Light Meters and Smartphone Light Meter App Comparison

In a time of increasingly powerful smartphones, there are apps for a wide variety of things that were once specialized and impossible to do without specific equipment. Examples include slow motion videos, GPS, complex videogames, and so on. The effectiveness of these apps could be questionable, however. The slow motion videos that can be taken with recent models of smartphones are high quality, but fall short of specialty equipment still. In the case of GPS, phones have done well to surpass older models of GPS, though they are still not as powerful as those GPS's that are fitted for the military or planes. Videogames on the phone are another example of the prowess of smartphones, though avid gamers would never call the phone their primary gaming device because of its many limitations. Typically, games on the phone are played just to pass time, so they serve their purpose. The average person wouldn't need a slow motion camera, GPS, or videogame any more powerful than the ones available in apps, so this difference in power and accuracy is not a problem.

Another example of a tool being implemented into an app is the light meter. Light meters are used by engineers, architects, botanists, photographers, and any other related profession to measure levels of sunlight or artificial light. Light meters typically measure the level of illuminance in lux or foot-candles. Building codes require specific light level ranges for different kinds of buildings and rooms based on their use. 1 lux is the amount of light that hits a 1 square meter surface when 1 lumen is shined from 1 meter away. Each foot-candle is roughly equivalent to 10 lux. Shown below are some common ranges that light levels should fall between:

ROOM TYPE	LIGHT LEVEL (FOOT CANDLES)	LIGHT LEVEL (LUX)
Bedroom - Dormitory	20-30 FC	200-300 lux
Cafeteria - Eating	20-30 FC	200-300 lux
Classroom - General	30-50 FC	300-500 lux
Conference Room	30-50 FC	300-500 lux
Corridor	5-10 FC	50-100 lux
Exhibit Space	30-50 FC	300-500 lux
Gymnasium - Exercise / Workout	20-30 FC	200-300 lux
Gymnasium - Sports / Games	30-50 FC	300-500 lux
Kitchen / Food Prep	30-75 FC	300-750 lux
Laboratory (Classroom)	50-75 FC	500-750 lux
Laboratory (Professional)	75-120 FC	750-1200 lux

Table 1: Light Level Recommendations

Source: Recommended Lighting Levels in Buildings

This report is an effort to determine the accuracy and effectiveness of light meter apps on smartphones when compared to an average industry light meter. The light meter model used is MT-912 "Urceri" Light Meter. There were three light meter apps that were tested: "Light Meter" by Elena Polyanskaya, "Luminos Meter" by Virtua Technologies, and "LightMeter" by Nipakul Buttua. The phone that these apps were tested on was the iPhone XS. The iPhone XS that was used was briefly tested against an iPhone SE and an Android phone, to ensure that the camera on the iPhone XS was not compromised. Each of these phone meters were tested alongside the industry light meter in the same spot at nearly the same time. Shown below are some of the results of these initial tests.

The following four charts are data corresponding to the initial tests done for the comparison of the “Light Meter” app by Elena Polyanskaya. The following tests are ordered in increasing Lux level readings.

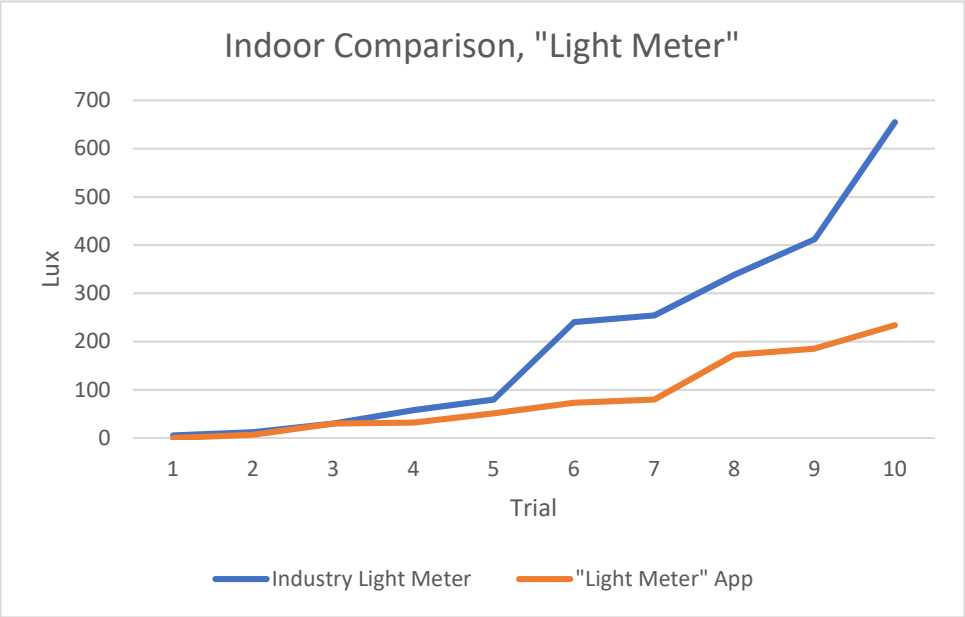


Figure 1**: Indoor** “Light Meter” app comparison with Urceri Light Meter

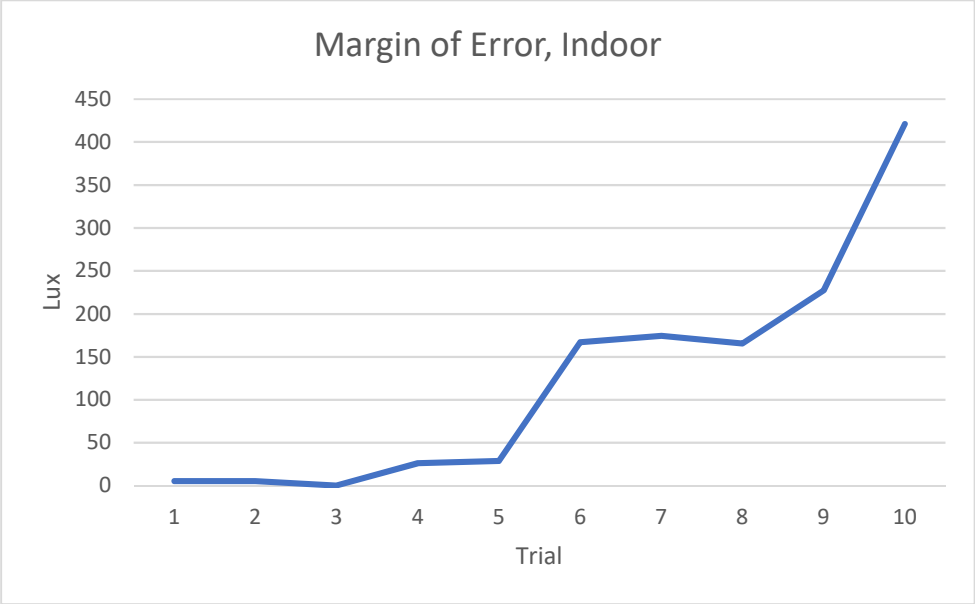


Figure 2: **Indoor** “Light Meter” app comparison error margin

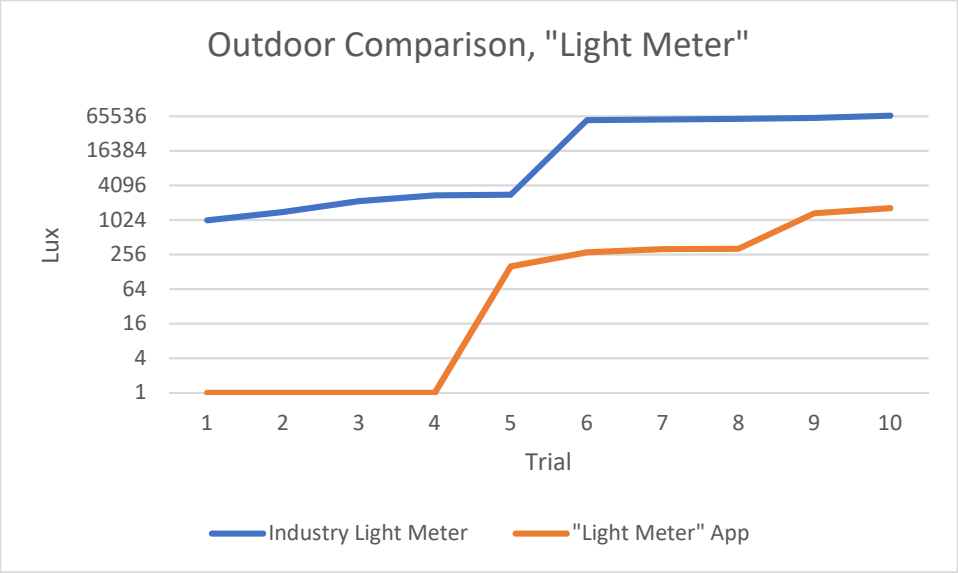


Figure 3: **Outdoor** "Light Meter" app comparison with Urceri Light Meter

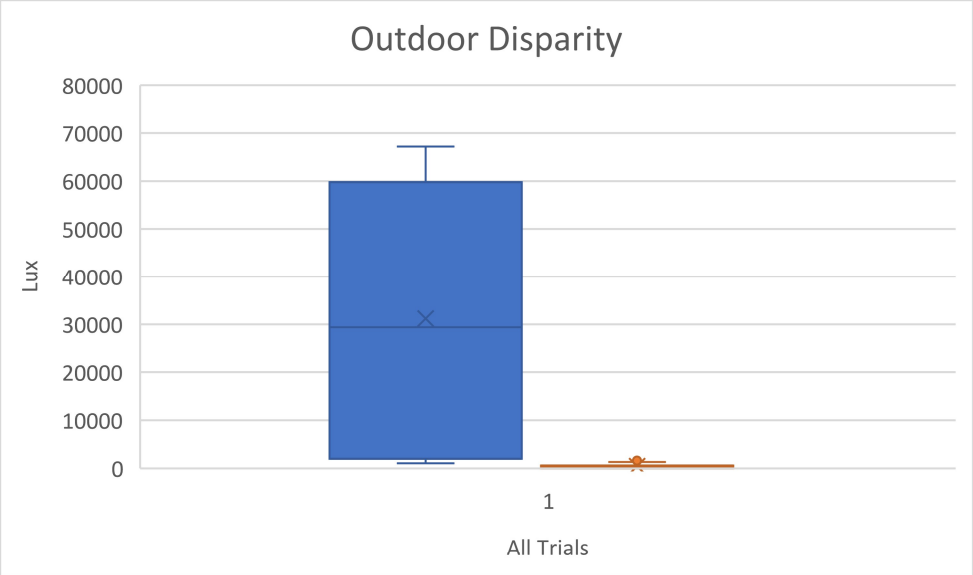


Figure 4: **Outdoor** "Light Meter" app comparison margin of error

It is more effective to show a trial-by-trial comparison when indoors, but the margin of error for most of the light meters were so drastic, that the same type of graphs did not provide a good enough visual representation.

The following four charts are data corresponding to the initial tests done for the comparison of the "LightMeter" by Nipakul Buttua. The following tests are ordered in increasing Lux level readings.

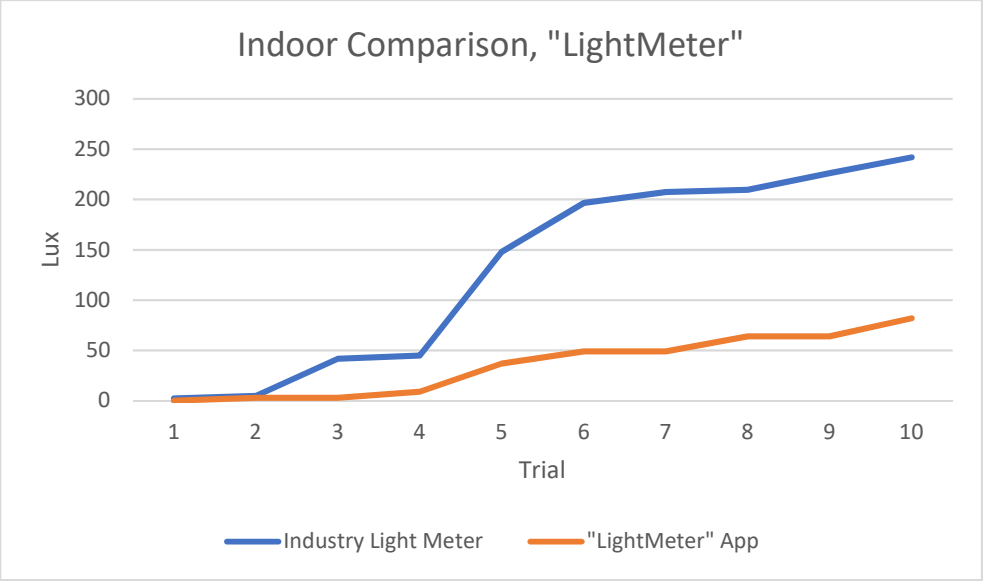


Figure 5**: Indoor** "LightMeter" app comparison with Urceri Light Meter

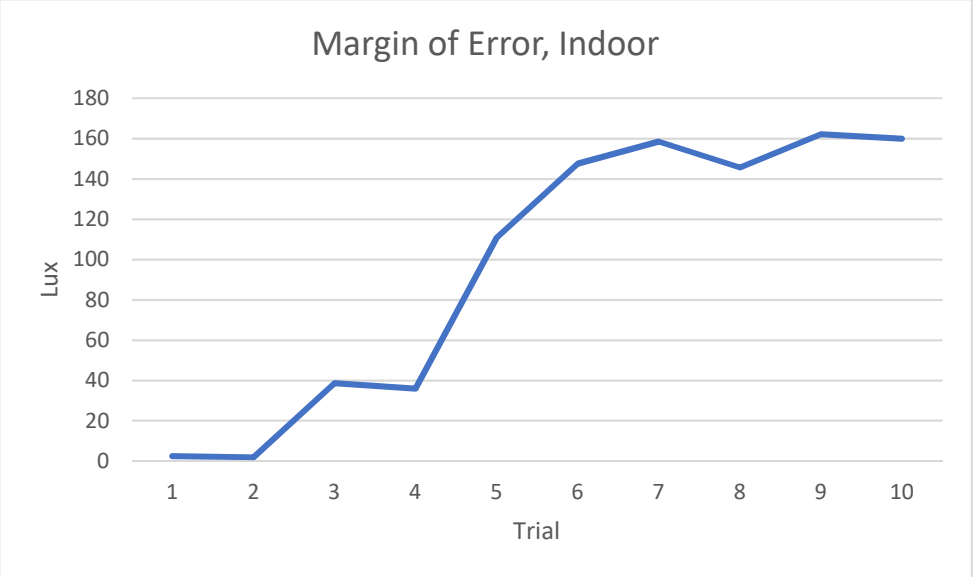


Figure 6**: Indoor** "LightMeter" app comparison margin of error

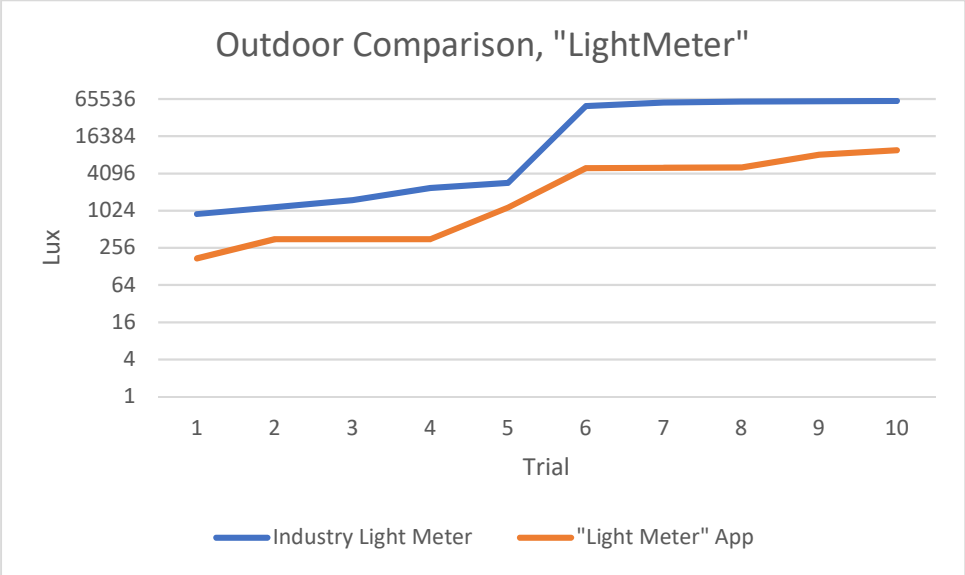


Figure 7: **Outdoor** "LightMeter" app comparison with Urceri Light Meter

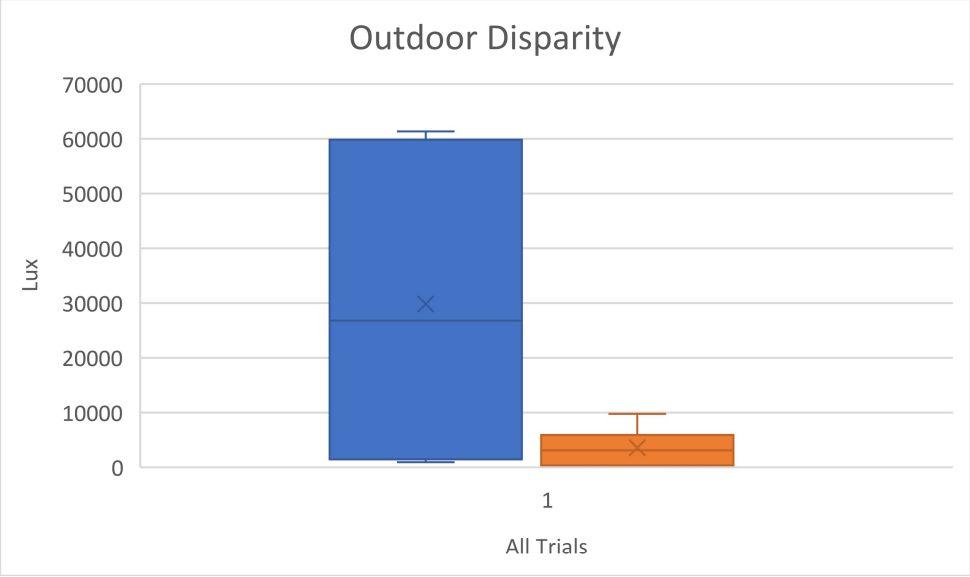


Figure 8: **Outdoor** "LightMeter" app comparison margin of error

The following four charts are data corresponding to the initial tests done for the comparison of the "Luminos Meter" by Virtua Technologies. The following tests are ordered in increasing Lux level readings.

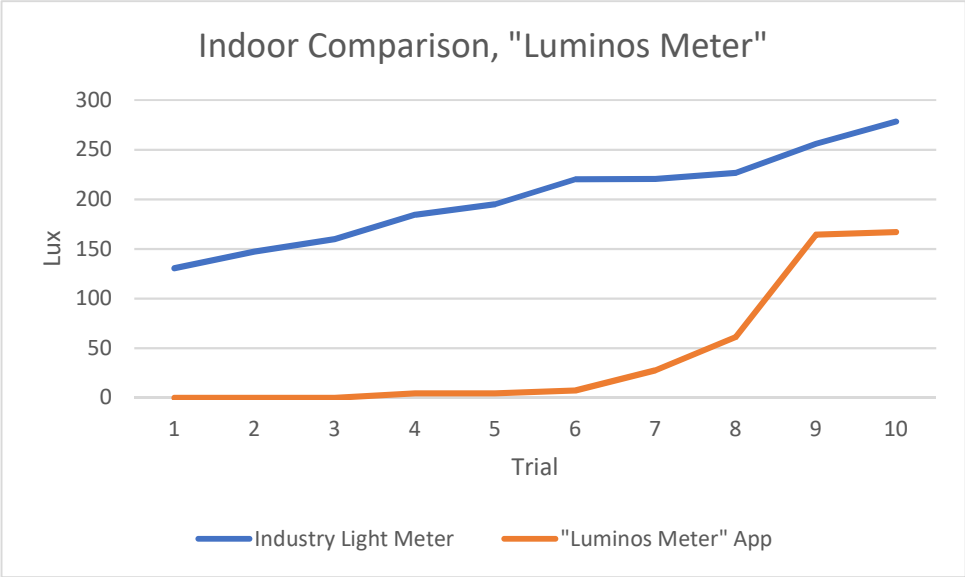


Figure 9: **Indoor** "Luminos Meter" app comparison with Urceri Light Meter

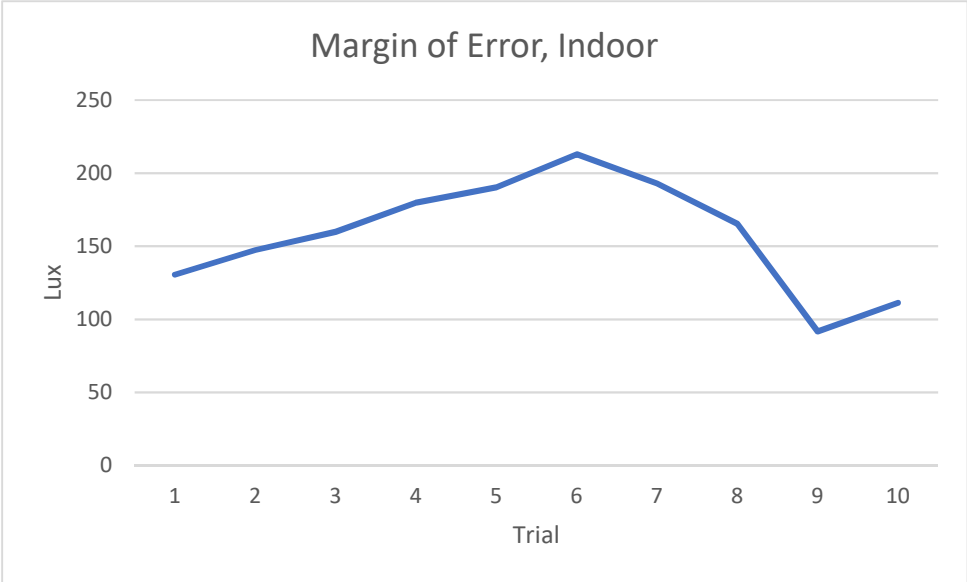


Figure 10: **Indoor** "Luminos Meter" app comparison margin of error

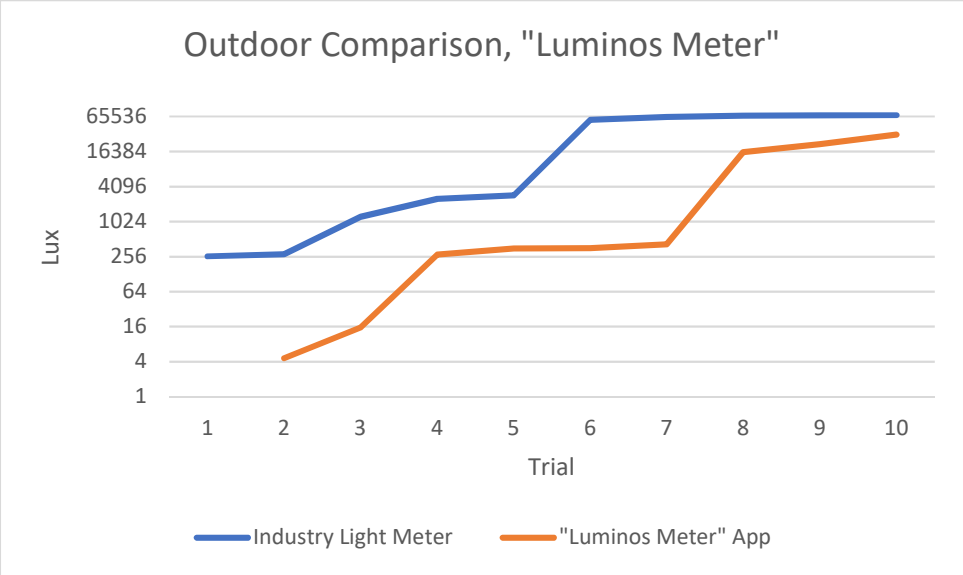


Figure 11: **Outdoor** "Luminos Meter" app comparison with Urceri Light Meter

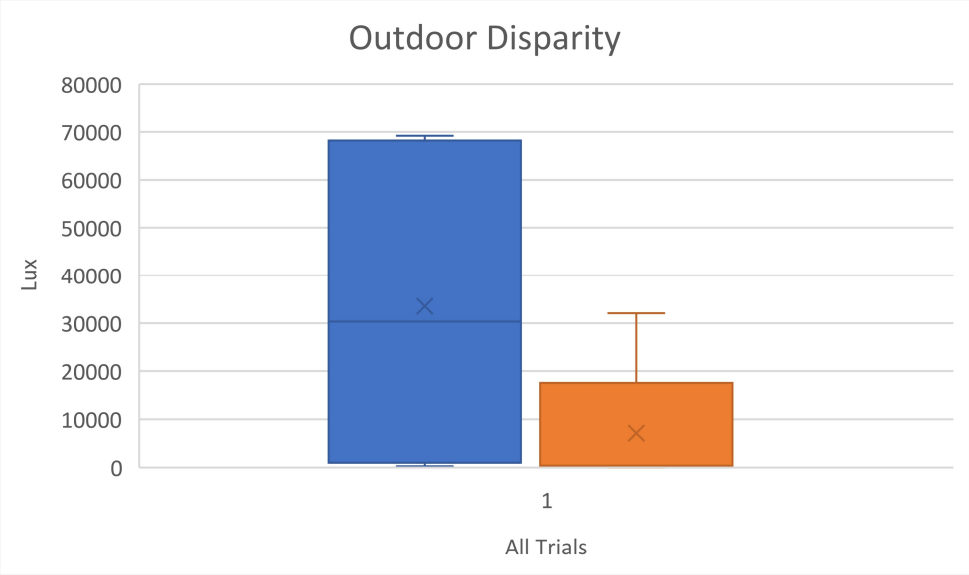


Figure 12: **Outdoor** "Luminos Meter" app comparison with Urceri Light Meter

While this Luminos Meter app had the most promising range of values outdoors, it was worse than the other two apps when it came to indoor readings. Despite this, the Luminos Meter was still not effective at getting accurate readings outdoors either.

From the raw data, it can be seen that the apps are not comparable to the industry light meter on average. The data that the apps collected were related and typically followed the trends that the industry light meter was exhibiting. The most accurate one according to the tests was the app "Light Meter" by Elena Polyanskaya. Therefore, this app was chosen to continue the examination and comparison. Although the readings followed trends indoors, they hardly did so outdoors, and especially not in direct sunlight. In some apps, there is a setting to turn on when indoors or outdoors, but even with these settings the results were not satisfactory. According to the error plots for each of the apps, the margin of error was significantly higher when doing the test outside, and even more so at higher Industry Lux meter readings. A couple of hypotheses were made prior to the following tests: The first is that it is possible that the app should be more accurate if more measurements are taken with a variety of angles and averaged. The second is that the app might base its light measurement off of only the direct light within the camera's view.

Rotational Average

In this test, the Industry light meter was tested alongside the smartphone light meter, but the phone was rotated 360 degrees. Every 30 degrees a measurement was taken and added to an average reading. The measurements were done about the same point within 30 seconds of each other. This test was done in an attempt to better simulate the nature in which the industry light meter collects light. Unlike the camera on a smartphone, most light meters have a dome shaped sensor that collects light from multiple angles. So if the smartphone were to be rotated at different angles to capture different quantities of light, the readings should more closely resemble that of the industry light meter. The results were promising, despite the data having wild fluctuations within each set. The average reading for the app ended up being within 100 lux of the industry reading.

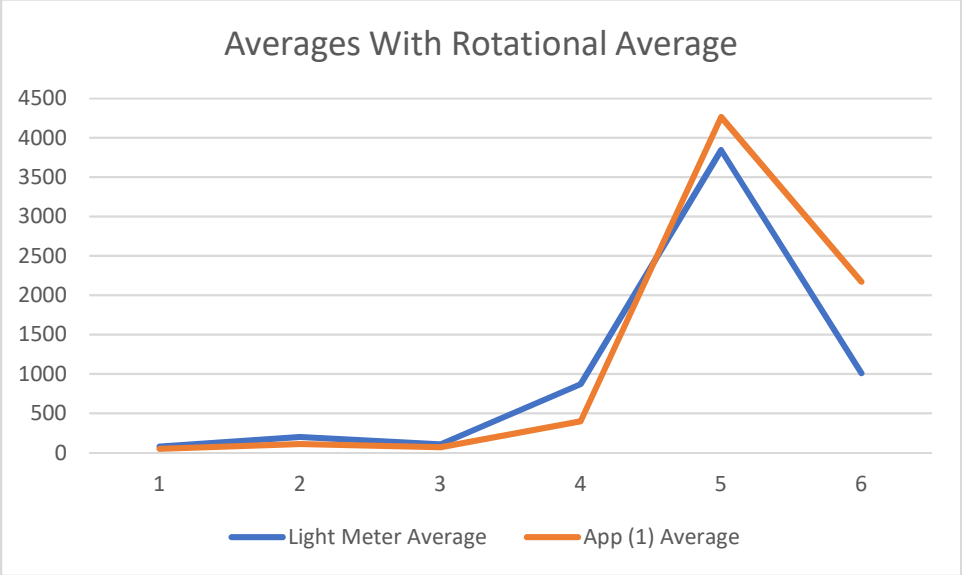


Figure 13: **Indoor** Comparison while rotating the phone 360 degree

Shown in table 2 to the right, the readings of the app fluctuate wildly as the phone is rotated, as would the industry light meter would if it was also rotated. For each value recorded from the industry light meter, 12 values were taken and averaged for the "Light Meter" app readings. This is an example of one of the plot points for figure 13, shown above.

Every 30 Degrees	
Light Meter Urceri (Average)	"Light Meter" App (1)
80.4	6
80.4	14
80.4	34
80.4	161
80.4	77
80.4	36
80.4	13
80.4	74
80.4	53
80.4	34
80.4	75
80.4	14
	49.25

Table 2: Example Measurement displaying a broad range of values from the rotational measurements

Although the values are above and below the actual measurement from the industry light meter, this was not always the case. In some tests, all values were drastically below or drastically above

the industry light meter reading. The data as a whole appears to more closely resemble the industry light meter's readings, though being able to predict, or implementing a correction factor is still not possible. Below is the full list of data points that are plotted on figure 13. Notice that there is no pattern or consistent gap between values.

Light Meter Average	App (1) Average
80.4	49.25
203.1	111.33
106.3	71.43
871.4	401.3
3846	4265.83
1010	2173.75

Table 3: Data from figure 13, showing the values from the rotational test.

While this was a promising test, it did not work out in direct sunlight. Considering the uses of light meters, it is not necessarily detrimental that the apps do not work in direct sunlight. The range of uses may be more limited, but if they are still accurate indoors and with indirect lighting, then the apps would be good enough to use.

Direct Light

The second test was to see if the measurement taken by the smartphone app was dependent on a direct light source. Some of the time, the app would read 0 lux, despite there being ample light shining into the camera. If there happened to be no direct bright lights within the camera's view, there is a possibility that the app does not measure. In addition, it is possible that the app measures disparity between the brightness of surfaces, so if the entire room is the same light level, the reading will be inaccurate. In order to test these hypotheses, a dark room was used. All measurements taken henceforth by the app were taken using a rotational average unless otherwise noted.

In the dark room, a single light was turned on with ample indirect light to still have readings elsewhere in the room. The theory that was being tested was that if the phone were to not have the light source directly within its camera view, the reading would be wildly inaccurate, and if the phone were moved slightly over so that it is within view, the reading would either spike above the readings of the actual light meter or it would more closely follow its trends. The below graph is the result of a set of tests.

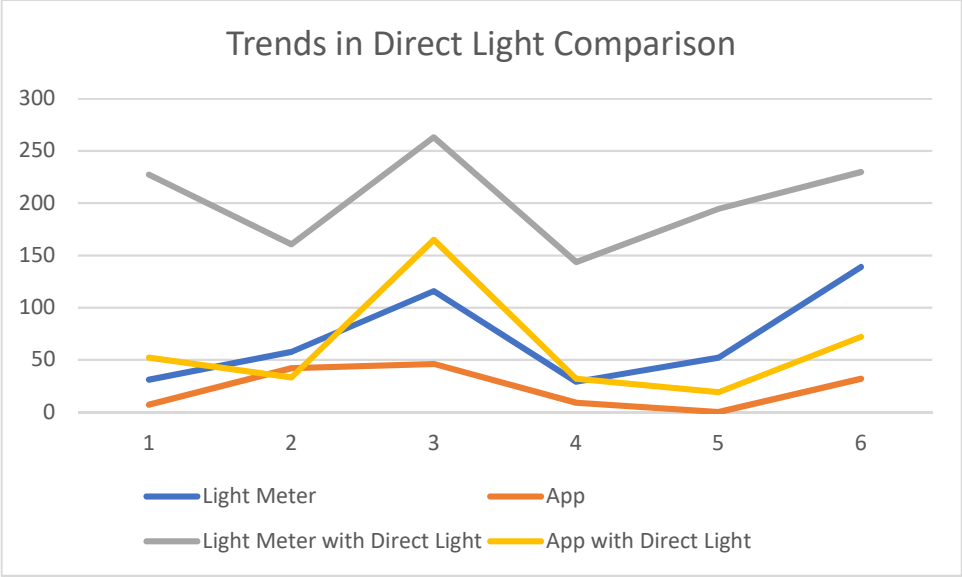


Figure 14: Trendlines between six different trials with direct light and indirect light.

The trend lines do not suggest that the theory is correct, and only further displays a consistent inaccuracy of readings, despite performing a rotational average for each and every app data point. In addition, while performing these tests, a strange discovery was made. First, a control measurement was taken at 700.6 Lux for the light meter and an average of 429 Lux for the app. Next, a very thin napkin was placed over either devices in an effort to dilute the direct light. The result was a reading of 329.9 Lux for the light meter and an average of 2193 Lux for the app. This is reproducible and works under warm, cool, and indirect light. The average disparity in measurements for this experiment was 2000 Lux.

In all the other tests, the industry light meter had higher readings on average than the app, though when a napkin is placed over the sensors, this trend completely reverses.

Reading on a Control Surface

Another test was conducted in order to test another possible correlation between how the smartphone apps record light data and how the industry light meter records light data. This test involved lighting a blank surface (whiteboard) and holding either light meter at a specified distance away from the surface at a specified height, as shown below:

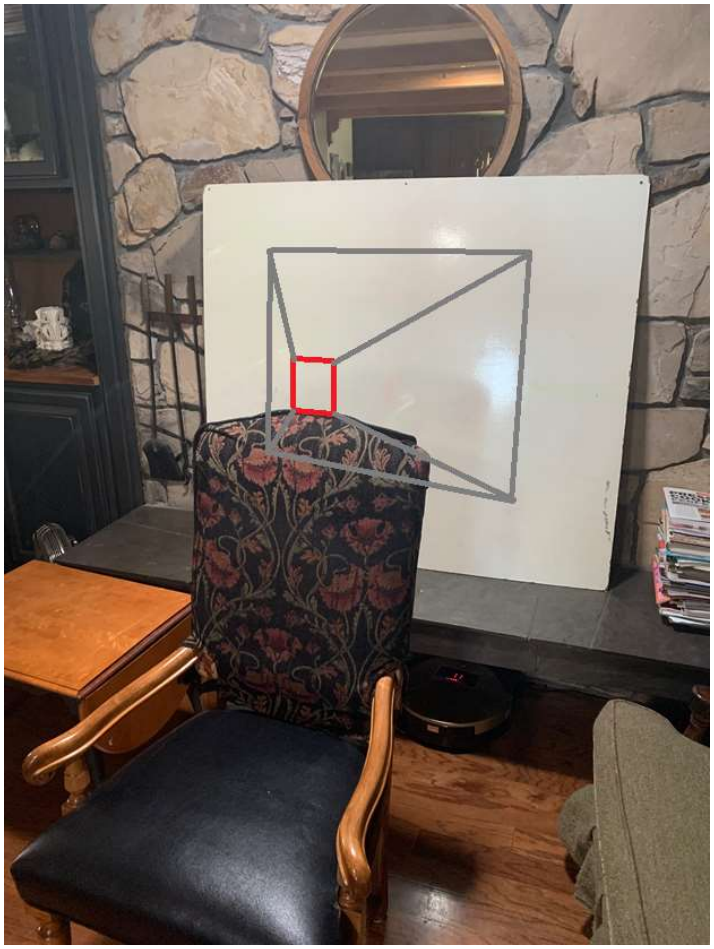
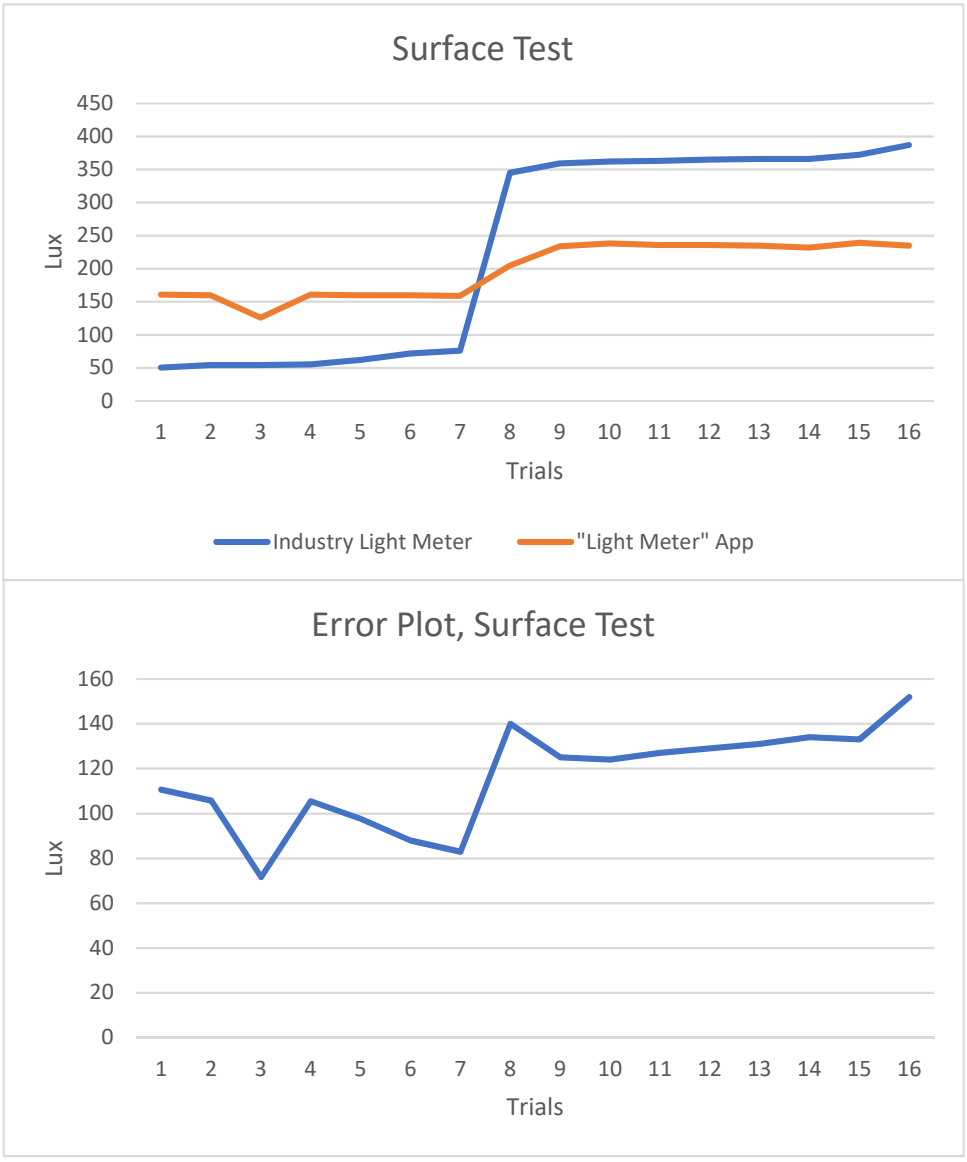


Figure 15: Phone placement and field of view. (Red is the phone, gray are its visual borders)

The scope of the camera on the smartphone was entirely within the bounds of the control whiteboard. The tests were done at a distance of 2 ½ feet from the white board. Changing the distance between the sensors and the whiteboard did not yield any significant difference in measurement disparities. The reason this test was conducted was to see if the smartphone app would be more accurate or precise when the objective was a very basic illuminance on a flat surface.



Figures 16, 17: Results of Surface Test and the margin of error between readings, respectively.

Conclusion

It is not the objective of this report to understand why or how the light meter apps work, but to investigate their effectiveness and accuracy compared to an official light meter. From the results, it can be seen that although the apps generally follow trends, their readings are far too inaccurate and inconsistent to be used in any professional setting. It should also be noted that the outliers in data sets for the app were removed prior to inputting any of the data into this report. Often times, the app light meter would fluctuate between 0 and absurd values such as the one shown below.

Figure 1: App light meter reading indoors; this value would be accurate if the phone were inside the sun.

References

Recommended Lighting Levels in Buildings. (n.d.). Retrieved June 01, 2020, from https://www.archtoolbox.com/materials-systems/electrical/recommended-lighting-levels-in-buildings.html