

# Unlocking the Wonders of the Night Sky with iSkyMatch App: A Smartphone-Based Astrophotography Companion

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Received: 02 February 2026 /Accepted: 1 March 2026 /Published online: 01 January 2027

## Abstract

Smartphone-based astrophotography is rapidly emerging as an accessible tool for astronomical observation. However, variability in imaging parameters such as exposure time, lens aperture, light intensity, and optical distance significantly affects reproducibility and photometric accuracy. Preliminary experimental colour-standardisation data obtained using an iPhone 4 camera demonstrated that brightness correction using a standardised parameter reduced variability dramatically. Imaging of 16 colours from Red-Violet across 50 varying optical conditions produced a standard deviation of approximately 3.42 after standardisation, compared to 33.18 without correction. Similarly, across all 16 colour standards, the mean standard deviation decreased from 37.12 to 4.87, confirming improved reproducibility. Statistical analysis was conducted using Microsoft Excel to calculate mean RGB values, standard deviations, error percentages, and post-hoc power estimation (power > 95%,  $\alpha = 0.05$ ,  $\beta \approx 0.05$ ). The iSkyMatch smartphone application (Version 1.0) integrates this colour-brightness standardisation methodology to enhance astrophotographic imaging and enable photon-percentage estimation for observational astronomy. The App facilitates deep-sky imaging, astrometry, photometry, variable star monitoring, aurora capture, comet tracking, and eclipse imaging using smartphone-telescope assemblies. This paper presents the operational framework, methodology, and preliminary performance outcomes of the

iSkyMatch system as a portable astrophotography companion.

**Keywords** Astrophotography · Brightness Correction · Colour Standardisation · iSkyMatch App · Photon Percentage Estimation · Smartphone Imaging · Sky Colour Matching

## 1. Introduction

Astrophotography has traditionally depended on high-cost imaging systems that require precise optical calibration [1-6] and controlled acquisition conditions [7-10]. Recent advances in smartphone camera technology, however, present a promising alternative pathway toward the democratization of observational astronomy [11].

Despite this progress, significant variability in imaging parameters — including exposure time, optical distance, lens aperture, and ambient light intensity — introduces inconsistencies in pixel brightness and colour fidelity [12-18]. These variations can compromise the reproducibility of observational data, particularly in applications such as astrometry, photometry [19, 20], and variable star monitoring [21].

To address these limitations, the iSkyMatch App [11, 22] that developed exclusively for iOS devices, including iPhone and iPad, and not available on other cross-platform systems or macOS, incorporates a colour standardisation methodology derived from controlled experimental

imaging datasets [23, 24]. This approach has demonstrated a substantial reduction in pixel variability across changing acquisition conditions [25, 26].

By mitigating brightness and colour inconsistencies [27, 28], iSkyMatch enables smartphones to function not merely as casual imaging devices [29, 30], but as semi-quantitative astronomical tools capable of supporting more reliable observational analysis [31, 32].

Furthermore, stabilisation of pixel brightness enables estimation of relative photon contribution within captured images [24, 34], allowing smartphone-based imaging to support semi-quantitative light analysis [11, 29, 30]. This capability extends the application of mobile astrophotography beyond visual documentation toward measurable observational consistency [34-36].

Based on prior experimental imaging datasets demonstrating significant reductions in colour variability following brightness standardisation, the present study hypothesises that: *Application of colour standardisation within smartphone-based astrophotography will significantly reduce pixel variability and error rates across RGB channels, thereby improving reproducibility and enabling reliable relative photon representation under variable imaging conditions.*

## 2. Methodology

The iSkyMatch system applies brightness correction and photon-percentage analysis using a standardized imaging workflow [11, 22].

### 2.1 Imaging Setup Procedure

Smartphone-based astrophotography was performed using a standard optical coupling method. The setup consisted of:

1. A smartphone mounted onto a commercially available adapter attached to the eyepiece of a telescope or binocular system.
2. Alignment of the smartphone camera lens with the optical axis of the eyepiece to

ensure optimal light transmission and image clarity.

3. Capture of celestial images under varying observational conditions for subsequent colour brightness correction and photon percentage analysis using the iSkyMatch App.



Fig. 1 Smartphone–Telescope optical

### 2.2 Image Processing Steps

#### 1. Getting Started:

- After installing iSkyMatch, tap the App icon to launch it.
- On the initial page (see Fig. 2), you'll find two essential links: one for a YouTube Video Instruction and another for sources of astronomical information related to using the iSkyMatch App.



Fig. 2 iSkyMatch App launch screen with instructional resources

2. **Selecting Your SmartPhone Image:**

- To pick a sky photo from your smartphone album, tap the top left rectangular arrow.

3. **Astrophotography Image Process Analysis:**

- For astrophotography brightness and colour correction analysis, click the top right green arrow, as highlighted in Fig. 3.



Fig. 3 Accessing image analysis via the top-right green arrow

4. **Measuring Photon Number Percentage (PhotonNo%):**

- Your smartphone screen will automatically display the processed colour image of your telescope/binocular photo in plain red.

- Now, a user has option to navigate by clicking through buttons at the top centre, presented in three separate segments:

- The first "Origin" button (as shown in Fig. 4) allows you to match the picked original image with other image processing buttons for astronomical image analysis comparison.



Fig. 4 Selecting the "Origin" button for image analysis comparison

- The "Corrected Brightness" button enhances the colour and brightness of your telescope/binocular photo for

improved astrophotography quality and resolution (Fig. 5).



Fig. 5 Applying corrected brightness enhancement

- The "Corrected Brightness" button enhances the colour and brightness of your telescope/binocular photo for improved astrophotography quality and resolution (Fig. 5).
- The "PhotonNo%" button processes the colour image to determine the Photon Number Percentage. Tap the centre of the red-coloured portrait, and at the bottom of the image, you'll see the estimated PhotonNo% value along with a slider magnitude at the top. You can choose to save or snapshot the red-coloured portrait with the estimated PhotonNo% value in your smartphone photo library album to record the

observed total Photon Number Percentage (Fig. 6).



Fig. 6 Estimating photon number percentage from selected image region

#### 5. Additional Analysis:

- To analyse another sky smartphone photo from your photo album, tap the top right rectangular arrow, similar to the steps outlined in Figures 4-7. This way, you can save multiple red portraits and their associated PhotonNo% values.

#### 6. Interpreting PhotonNo% Discrepancy:

- In general, you can assess the reliability and reproducibility of astronomical matching by comparing PhotonNo% values between two red-coloured portraits:
  - PhotonNo% differences greater than 5% indicate no astronomical colour matching.

- Differences between 1% and 5% PhotonNo% suggest moderate astrophotography similarity.
- A 1% difference indicates substantial similarity.
- A 0% difference implies almost perfect astronomical matching.

| PhotonNo% Difference | Interpretation        |
|----------------------|-----------------------|
| > 5%                 | No astronomical match |
| 1–5%                 | Moderate similarity   |
| 1%                   | Strong similarity     |
| 0%                   | Near-perfect match    |

**Table 1** Interpretation of photon matching

These criteria provide a structured framework for interpreting PhotonNo% discrepancies and assessing the reproducibility of astronomical image matching.

### 3. Results

Statistical analysis was performed using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) to evaluate mean RGB values, standard deviations (SD), and error percentages across the 16 colour standards.

To assess whether colour standardisation remains effective under smaller observational datasets, a representative subset of 50 imaging conditions was analysed using an iPhone 4 smartphone camera (Apple Inc., Cupertino, California, USA).

For the single Red–Violet standard, the standardised dataset demonstrated a markedly lower variability, with an estimated SD of **3.42**, compared to **33.18** in the non-standardised dataset. This confirms that substantial reproducibility improvement is maintained even with reduced sampling.

Across all 16 colour standards, similar trends were observed. Standardised pixel values consistently showed lower variability and reduced error percentages. The estimated mean SD decreased from **37.12 (non-standardised)** to **4.87**

(**standardised**), while the mean error percentage declined from **67.84%** to **46.15%**.

These values closely follow the stability pattern observed in the full dataset, indicating that the standardisation process is robust and not dependent on large image volumes.

Post-hoc power estimation for 50 imaging conditions, assuming a significance level of  $\alpha = 0.05$  and the observed effect magnitude, indicated a statistical power exceeding **95%** ( $\beta \approx 0.05$ ), demonstrating that meaningful variability reduction can be reliably detected even in smaller observational sets.

| Channel     | Standardised |              | Non-standardised |              |
|-------------|--------------|--------------|------------------|--------------|
|             | SD           | Error %      | SD               | Error %      |
| Red         | 6.12         | 47.08        | 41.03            | 58.21        |
| Green       | 4.98         | 43.62        | 36.87            | 66.74        |
| Blue        | 3.52         | 47.75        | 29.46            | 78.02        |
| <b>Mean</b> | <b>4.87</b>  | <b>46.15</b> | <b>37.12</b>     | <b>67.84</b> |

**Table 2** Multi-colour dataset (16 Standards) – Standard Deviation (SD) and Error Percentage

These findings confirm that brightness and colour standardisation implemented in the iSkyMatch App enhances reproducibility even under limited sampling conditions, supporting reliable photon percentage estimation and improved consistency in smartphone-based astrophotography measurements.

### 4. Discussion

The findings demonstrate that the iSkyMatch App [11, 22] improves the reproducibility of smartphone-based astrophotography [37, 38]. In the 50-image subset, brightness and colour standardisation [8, 10, 14, 17] substantially lowered variability, with the Red–Violet standard showing a reduction in standard deviation from approximately 33.18 to 3.42, and the multi-colour dataset (16 standards) decreasing from 37.12 to 4.87. This reduction indicates that the standardisation process effectively compensates for fluctuations introduced by exposure time, optical distance,

ambient light intensity, and lens characteristics [22, 25, 28]. In parallel, the mean error percentage decreased from 67.84% to 46.15%, confirming that image consistency improves in terms of dispersion.

Post-hoc power estimation further supports the stability of these observations. For 50 imaging conditions at a significance level of  $\alpha = 0.05$  and a large observed effect size ( $d \approx 0.82$ ), the estimated statistical power exceeded 95% ( $\beta \approx 0.05$ ). This indicates that meaningful improvements in colour reproducibility can be confidently detected without requiring extensive image acquisition [11, 22].

From a practical astrophotography perspective, these improvements are highly significant:

- 1) **Deep-Sky Imaging:** Consistent colour correction ensures that faint nebulae, galaxies, and star clusters are accurately captured, minimizing artefacts caused by variability in imaging parameters [39].
- 2) **Photon Number Estimation:** Reliable standardisation enables more precise photon percentage calculations, improving photometric measurements and tracking of variable stars [40].
- 3) **Time-Lapse and Event Capture:** Comets, meteor showers, eclipses, and aurorae can be documented with greater quantitative reliability, facilitating longitudinal studies and comparison between sessions [41, 42].
- 4) **Amateur Accessibility:** By integrating complex brightness correction and photon estimation into a smartphone App, iSkyMatch empowers both amateur and professional astronomers to conduct semi-quantitative observations without specialized imaging hardware [11, 22].

In summary, the statistical and practical analyses confirm that iSkyMatch transforms smartphone-based astrophotography from a qualitative hobby into a semi-quantitative observational tool. The combination of colour standardisation [24], photon estimation [21, 33, 35], and robust statistical validation ensures that users can confidently document celestial phenomena with reproducible and scientifically meaningful results [41].

## 5. Conclusion

The iSkyMatch App demonstrates that smartphone-based astrophotography can achieve strong reproducibility and quantitative reliability through brightness and colour standardisation [24], even with reduced observational datasets. Experimental analysis across 16 colour standards using 50 imaging conditions showed substantial reductions in variability and error percentages, supported by post-hoc power analysis (power > 95%,  $\alpha = 0.05$ ,  $\beta \approx 0.05$ ).

By integrating adaptive colour correction and photon percentage estimation [21, 33, 35], iSkyMatch enables more consistent imaging of celestial objects under variable observational conditions [11, 22]. This supports practical applications such as deep-sky imaging [39], variable star monitoring, comet tracking, and eclipse documentation [41-44].

Overall, the results indicate iSkyMatch a practical and accessible tool that helps bridge the gap between amateur observation and semi-quantitative astronomical imaging [11, 22].

## 6. Author Declarations and Disclaimers

**6.1 Astronomical Disclaimer:** The iSkyMatch App is designed for astrophotography and astronomical observation purposes only. It does not replace professional astronomical instruments or advisory services. All measurements, photon percentage estimates, and image corrections are intended for informational and educational use. Users are encouraged to validate findings with appropriate observational or professional tools.

**6.2 Privacy Notice:** The iSkyMatch App adheres to current data protection regulations (e.g., GDPR). Any user images or data captured within the App are stored locally on the user's device unless explicitly exported. No personal or image data are shared with third parties without informed consent. Users may access, modify, or delete their data at any time.

**6.3 Conflict of Interest:** The author is the developer of the iSkyMatch App and declares that this publication is intended solely for scientific, educational, and instructional purposes related to astrophotography and astronomical data analysis. No external commercial influence affected the preparation of this work.

**6.4 Funding:** The development of the iSkyMatch App and the preparation of this manuscript were self-funded by the author. No external funding sources contributed to the work.

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