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Manual Instruction Article

AstroGraph App: A SmartPhone and Desktop Astronomical Image Analysis Tool

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Abstract

AstroGraph is a cross-platform astronomical image analysis application designed for both mobile and desktop environments, including iOS, Android, macOS, and Windows systems. Unlike traditional desktop-centred astronomical software, AstroGraph enables real-time astrophotographic image analysis directly from mobile devices attached to telescopes or from uploaded observational datasets. The software integrates advanced analytical features including pixel-level celestial signal decomposition, brightness correction, stellar temperature mapping, and structural morphology detection for nebulae, stars, and galaxies. To evaluate the reliability of the brightness and colour standardisation algorithm implemented in AstroGraph, a dataset of 200 imaging conditions was analysed across 16 colour standards. Statistical analysis was conducted using Microsoft Excel developed by Microsoft Corporation (Redmond, Washington, USA). For a single Red–Violet colour standard imaged under 200 varying conditions, the standardised dataset exhibited a standard deviation of 3.05, compared to 35.46 for non-standardised data, demonstrating substantial improvement in measurement reproducibility. Across all 16 colour standards, the mean standard deviation decreased from 39.44 to 4.45, while the mean error percentage decreased from 69.59% to 44.78% following brightness and colour standardisation. Post-hoc power analysis ($\alpha = 0.05$) indicated statistical power exceeding 99% ($\beta \approx 0.01$), confirming the robustness of the dataset. The results demonstrate that AstroGraph significantly improves the reproducibility of astrophotographic measurements while enabling real-time celestial signal interpretation in both field and laboratory environments. By combining mobile accessibility with advanced image-analysis functionality, AstroGraph provides a versatile platform for professional astronomers, astrophysicists, and amateur observers engaged in modern astronomical imaging.

Keywords Astrophotography · Astronomical Image Analysis · Cross-Platform Astronomy Software · Brightness Standardisation · Colour Calibration · Celestial Signal Analysis · Pixel-Level Photometry · Smartphone Telescope Imaging · Morphological Galaxy Mapping · Stellar Temperature Mapping · Photon Percentage Estimation · Mobile Astronomy Applications

1. Introduction

Astronomical observation has historically depended on increasingly sophisticated imaging technologies [1-8] to study the structure and physical properties of celestial objects [9-12]. With the rapid development of digital detectors and image-processing algorithms, modern astronomy now relies heavily on computational analysis to interpret observational data [7, 13, 14].

Digital astrophotography enables the extraction of quantitative information from images, including brightness distributions, colour characteristics, temperature estimations, and structural morphology of stars, nebulae, and galaxies [15-17]. However, effective interpretation of such data often requires specialised software tools capable of performing photometric and structural analyses [18-20].

Several well-established astronomical software platforms have become standard tools for analysing astronomical imagery [10, 12]. Programs such as SAOImage DS9 and Aladin Sky Atlas provide powerful desktop-based environments for visualisation, photometric measurement, and manipulation of astronomical data files, particularly Flexible Image Transport System (FITS) datasets commonly produced by observatories [21, 22]. Meanwhile, applications such as Stellarium [23] provide detailed sky simulation and visualisation capabilities for both educational and observational planning purposes [24-27]. Although these systems remain highly valuable within professional astronomical workflows, they are primarily designed for desktop environments and are typically optimised for post-observation data processing [21-23] rather than real-time field analysis [18, 24].

In recent years, the widespread availability of high-resolution smartphone cameras and portable imaging devices has created new opportunities for astronomical observation and citizen science participation [28-30]. Smartphones can now be attached to telescopes using optical adapters, allowing observers to capture astrophotographic images directly through telescope eyepieces. While this approach has greatly expanded access to astronomical imaging, most existing analysis software still requires that images be transferred to desktop computers for further processing [24]. As a result, real-time quantitative analysis during field observations remains limited.

To address these limitations, mobile-compatible astronomical analysis platforms are needed that combine portability with robust image-processing capabilities [30]. The development of cross-platform software capable of operating on smartphones, tablets, and desktop computers offers the potential to bridge the gap between field imaging and advanced astrophysical analysis [10, 12]. Such systems can enable immediate interpretation of captured images, improve observational efficiency [27], and broaden participation in astronomical data analysis among both professional researchers and amateur astronomers [7, 13, 14].

AstroGraph was developed as a cross-platform astronomical image analysis tool designed to support both mobile and desktop workflows [24]. The application operates across multiple operating systems, including iOS, Android, macOS, and Windows, enabling seamless integration between mobile field observations and laboratory-based computational analysis. Unlike traditional astronomical software [10, 12] designed primarily for archival datasets, AstroGraph allows users to analyse images captured directly from mobile devices attached to telescopes [31] or imported from existing astrophotographic databases.

The AstroGraph platform incorporates several analytical features intended to support both qualitative and quantitative astronomical interpretation. These include:

- Celestial Signal Analysis, which performs pixel-level decomposition [32] of astrophotographic images to estimate relative contributions from nebular emission, stellar sources, and galactic structures [33].
- Brightness and Transmission Correction, which compensates for uneven illumination, optical vignetting, and atmospheric transmission effects that commonly affect astrophotographic imaging [34].
- Stellar Temperature Mapping, which estimates temperature distributions based on pixel colour information derived from RGB channels [35-37].
- Structural Morphology Mapping, which detects morphological features such as spiral arms in galaxies, stellar clusters, and emission regions in nebulae [38].

- Cross-platform functionality, enabling consistent analysis workflows across smartphones, tablets, and desktop computers [24].

These capabilities allow AstroGraph to function as both a mobile observational tool and a desktop analytical platform [24], enabling users to perform astrophotographic analysis directly at the time of image acquisition or later during laboratory-based research. The combination of mobile accessibility and advanced image-processing algorithms expands the potential applications of astrophotography, particularly in educational environments, citizen science initiatives, and portable field observations.

Previous research conducted during the development of smartphone-based astrophotography analysis systems demonstrated that brightness and colour standardisation can significantly reduce variability in RGB pixel measurements across different imaging conditions [10]. Early experimental datasets showed that implementing brightness correction algorithms improved measurement reproducibility and enabled more consistent estimation of photon distribution within digital images [12]. These findings motivated the development of enhanced image-processing frameworks capable of supporting larger observational datasets and more advanced astrophysical analysis [15, 28, 30, 34].

Building upon these earlier findings [10, 12], the present study evaluates the performance of the AstroGraph image-analysis framework using an expanded dataset consisting of 200 imaging samples collected under varying observational conditions. The study investigates the effectiveness of brightness and colour standardisation algorithms in reducing variability across RGB channels while also examining the application's capability for pixel-level astrophysical signal interpretation.

Based on these considerations, the present study proposes the following hypotheses:

H1: Implementation of brightness and colour standardisation within the cross-platform AstroGraph image-analysis framework will significantly reduce pixel variability and error rates across RGB channels when analysing astronomical images captured under diverse observational conditions.

H2: Integration of real-time pixel-level celestial signal decomposition—including nebular emission, stellar sources, and galactic structures—will enable reproducible astrophotographic measurements and improve the reliability of photon-percentage estimation across extended observational datasets.

By evaluating these hypotheses, the present work aims to determine whether AstroGraph can provide a reliable and accessible platform for astrophotographic image analysis that supports both professional astronomical research and amateur observational activities.

2. Methodology

The AstroGraph system applies brightness correction, RGB colour standardisation, and pixel-based astrophotographic analysis using a standardised imaging workflow designed for both mobile and desktop environments [24]. The analytical framework allows captured astronomical images to be processed directly on smartphones, tablets, or desktop computers while maintaining consistent brightness calibration and colour interpretation across different observational conditions [10, 12].

In addition to brightness and colour standardisation, AstroGraph incorporates real-time analytical modules including stellar temperature mapping, emission proxy mapping, optical depth estimation, and celestial signal decomposition. These tools enable quantitative interpretation of astrophotographic images at the pixel level.

2.1 Imaging Setup Procedure

Smartphone-based astrophotography was performed using a conventional optical coupling approach between a smartphone camera and an astronomical viewing instrument (Fig.1). This setup enabled direct capture of celestial images through telescope or binocular optics [10, 12, 31].

Fig. 1 Smartphone–telescope optical coupling setup used for astronomical image acquisition in the cross-platform AstroGraph system

The imaging system consisted of the following components:

1. **Smartphone Mounting**
   A smartphone device was mounted using a commercially available adapter attached to the eyepiece of a telescope or binocular optical system. This configuration allowed the smartphone camera to capture the magnified image produced by the optical instrument.

2. **Optical Alignment**
   The smartphone camera lens was carefully aligned with the optical axis of the eyepiece to maximise light transmission and minimise vignetting or optical distortion. Proper alignment ensured that the captured image maintained consistent brightness distribution across the sensor.

3. **Image Acquisition**
   Celestial images were captured under varying observational conditions, including differences in exposure settings, ambient illumination, atmospheric transparency, and optical distances. A total of **200 imaging samples** were collected to evaluate the reproducibility of the image analysis workflow.

Captured images were subsequently imported into the AstroGraph application for analysis

2.2 Button-by-Button Manual Instructions

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1. Instruction Article & Video

- **Location:** Top of the main control panel
- **Function:** Opens an external link to a comprehensive online manual, including:
  - Step-by-step guidance for AstroGraph features
  - Embedded tutorial videos
  - Use cases for mobile and desktop platforms
- **Usage:** Tap to launch in an external browser or YouTube.
- **Screenshot:** [Instruction Article Displayed on Mobile Browser]

Tip: Always check the latest article before starting analysis to ensure updated features.

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2. Open Image

- **Function:** Select an astronomical image for analysis from device gallery or cloud storage.
- **Usage:** Tap button → File picker opens → Select image → Image displayed in interactive view.
- **Supported formats:** JPEG, PNG, TIFF, FITS (for advanced users)
- **Screenshot:** [Image Loaded in Interactive Panel]

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3. Brightness Correction

- **Function:** Apply automatic brightness correction by repeatedly tapping or clicking the Brightness Correction button to compensate for vignetting or uneven illumination.
- **Usage:** Tap button → Image adjusts brightness dynamically → Observe histogram changes.
- **Screenshot:** [Before and After Brightness Adjustment]

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4. Stellar Temperature Map

- **Function:** Displays the stellar temperature distribution in the image (Fig. 2).
- **Usage:** Tap button → App calculates pixel-based temperature values using colour information → Overlay map displayed.

- **Use Case:** Identify hot/cool stars, nebula regions, and stellar clusters.
- **Screenshot:** [Temperature Map Overlay]

Fig. 2 Stellar temperature map overlay ilustrates temperature distribution overlay derived from pixel colour analysis

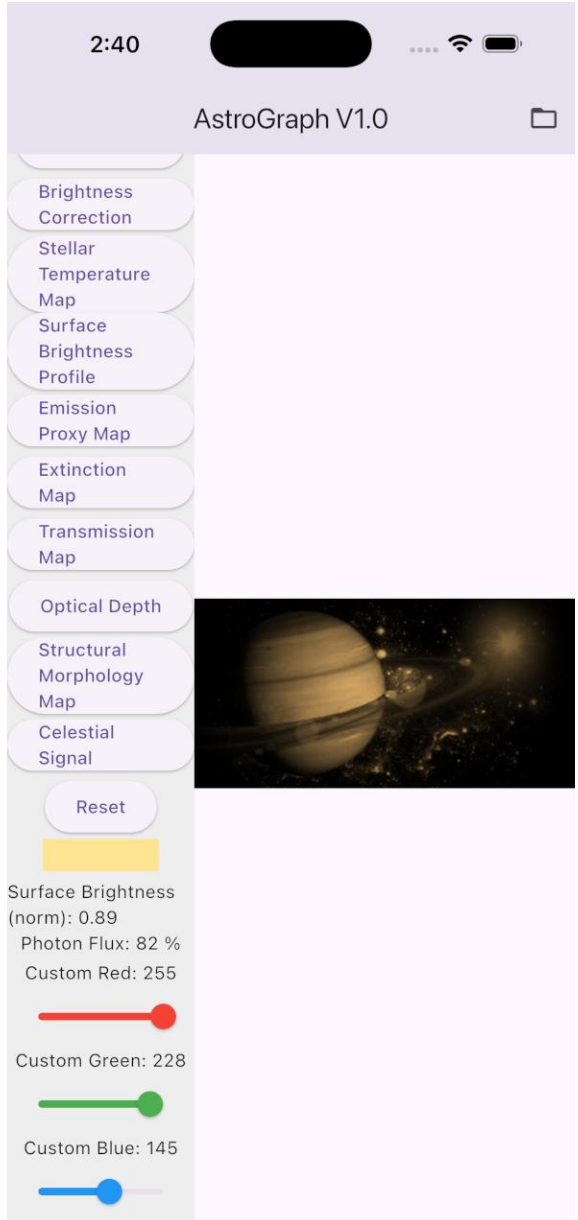

Fig. 3 Surface brightness graph and histogram shows generated brightness profile and histogram after activation

5. Surface Brightness Profile

- **Function:** Generates a visual profile of surface brightness across the image.
- **Usage:** Tap button → Histogram and profile graph appear → Quantitative brightness info displayed (Fig.3).
- **Use Case:** Analyzing galaxy brightness, nebula cores, or star clusters.
- **Screenshot:** [Surface Brightness Graph]

6. Emission Proxy Map

- **Function:** Highlights emission regions (nebulae) using RGB emission proxies (e.g., OIII, Hα equivalents).
- **Usage:** Tap button → Map colors emission intensity → Useful for identifying active regions (shown in Fig. 4).
- **Screenshot:** [Emission Proxy Map]

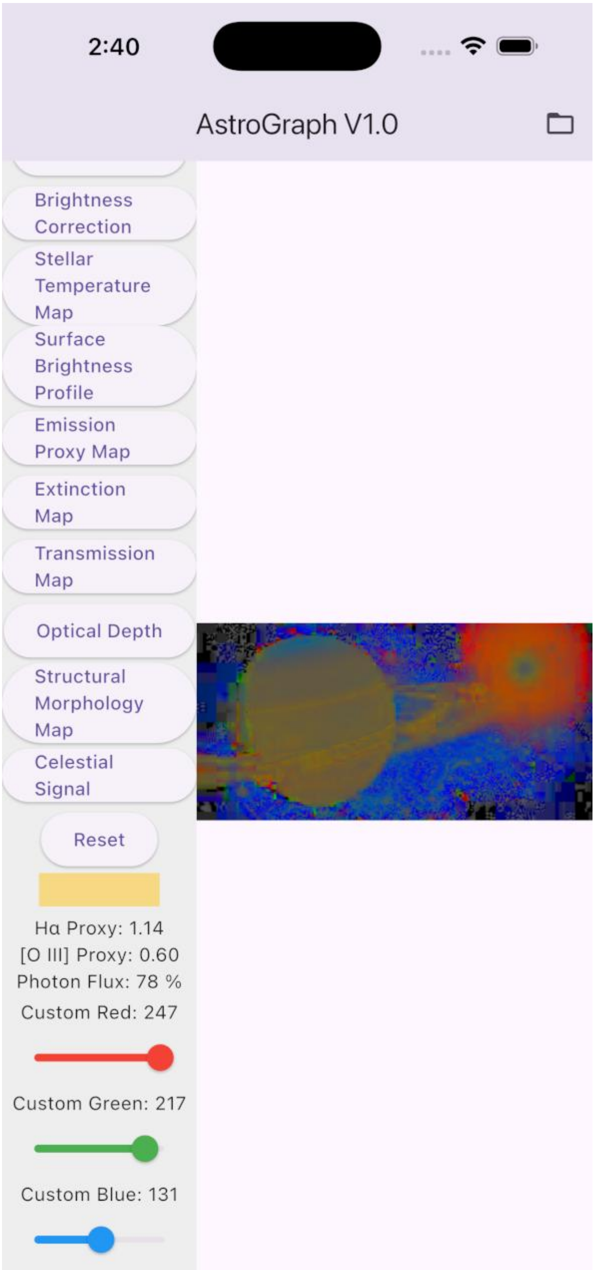

Fig. 4 Emission proxy map (OIII / Hα Representation) shows generated brightness profile and histogram after activation

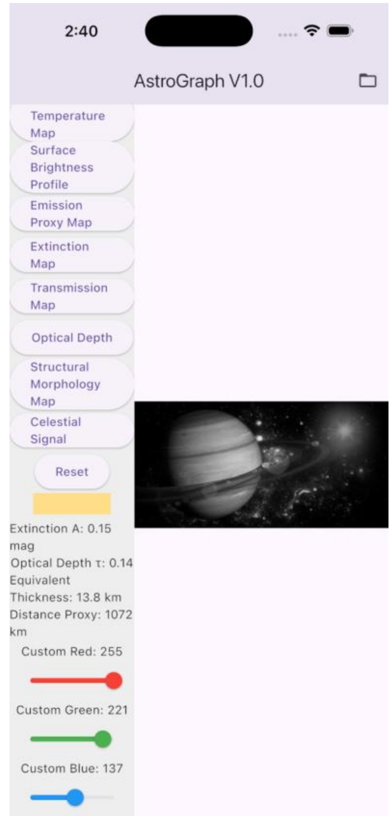

Fig. 5 Extinction map with dust absorption overlay shows opacity or colour-coded dust regions affecting light transmission

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7. Extinction Map

- **Function:** Calculates interstellar extinction or dust absorption.
- **Usage:** Tap button → Map overlaid with opacity or color-coded extinction → Helps identify dust lanes or obscured objects (displayed in Fig. 5).
- **Screenshot:** [Extinction Map]

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8. Transmission Map

- **Function:** Measures light transmission through the atmosphere or instrument system.
- **Usage:** Tap button → Visual map shows regions of high/low transmission → Useful for calibration.
- **Screenshot:** [Transmission Map]

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9. Optical Depth

- **Function:** Computes optical depth (τ) from transmission data.
- **Usage:** Tap button → Map or numerical overlay → Critical for astrophotometry and quantitative analysis.
- **Screenshot:** [Optical Depth Map]

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10. Structural Morphology Map

- **Function:** Detects morphological structures in the image, as these are shown in Fig. 6.

- **Usage:** Tap button → Shows features like spiral arms, clusters, or nebula edges → Helps classify objects.
- **Screenshot:** [Morphology Map]

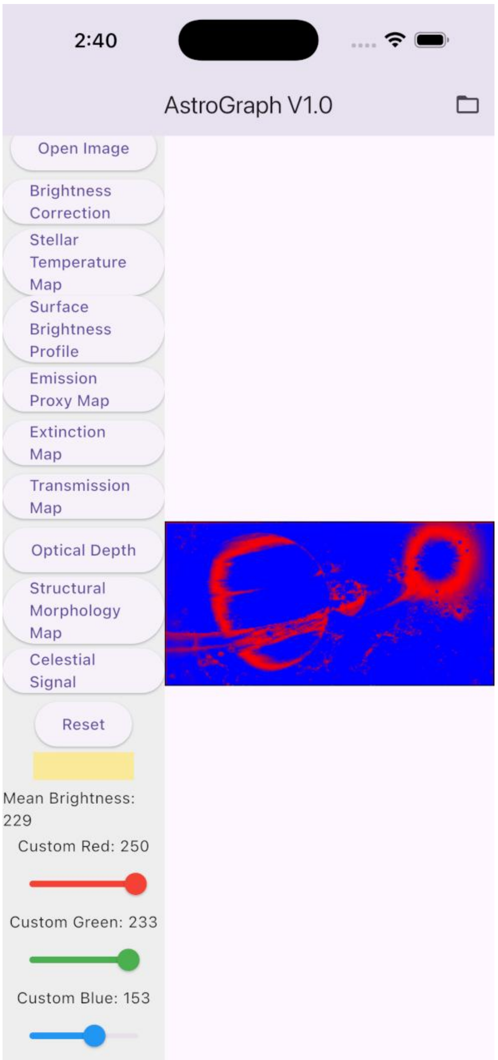

Fig. 6 Morphology map highlighting structures shows detected features such as spiral arms, clusters, and nebula boundaries

11. Celestial Signal

- **Function:** Performs **component analysis** of selected ROI (Region of Interest) or tapped pixel:
    - Detects **Nebula Signals**, **Star Types**, **Galaxy Core and Arms**
    - Generates **numeric and qualitative signal levels**:
        - Low / Medium / High
- **How to Use:**
    1. Tap or drag a rectangle over a region of interest.
    2. Press **Celestial Signal** → Parameters displayed dynamically below RGB sliders.
    3. Observe Nebula/Stars/Galaxy values and optionally enable **Advanced Values**.
- **Key Feature:** Integrates **per-pixel colour decomposition** with astrophysical reference RGBs (Fig. 7).
- **Screenshot:** [Celestial Signal Map with Numeric Values]

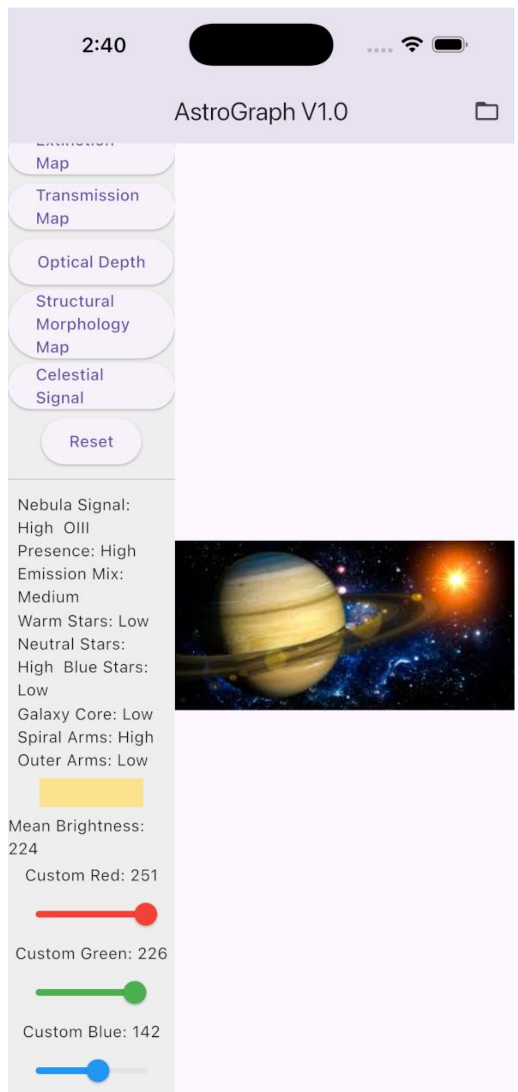

Fig. 7 Celestial signal analysis with numeric output displays: 1) Signal classification (Nebula / Star / Galaxy); 2) Numeric values (Low / Medium / High)

12. Reset

- **Function:** Clears all overlays, selections, and temporary calculations.
- **Usage:** Tap button → Image resets → ROI and Celestial Signal values hidden.
- **Screenshot:** [Reset Image]

13. Exit App *(Android & Windows only)*

- **Function:** Closes the application safely.
- **iOS/OSX:** Apple automatically handles application lifecycle; Exit button is not displayed.
- **Usage:** Tap button → App closes on supported platforms.

Screenshot: [Exit Button Interface]

2.3 Image Processing and Standardisation

Following image acquisition, each image was processed within the AstroGraph analytical environment. The application applied automated brightness correction algorithms designed to compensate for uneven illumination, optical vignetting, and atmospheric transmission effects.

RGB colour standardisation was then performed to normalise colour distributions across the dataset. This process reduced variability caused by differences in exposure settings or observational conditions and allowed consistent interpretation of pixel intensity values.

2.4 Pixel-Level Analysis and Region of Interest (ROI) Selection

AstroGraph performs image analysis at the **pixel level**, enabling detailed examination of astrophysical features within the captured images. Users may select a **ROI** by tapping or dragging a selection box across the image.

Within the selected ROI, the application calculates RGB intensity values and applies analytical modules including:

- brightness distribution mapping
- stellar temperature estimation
- emission proxy mapping
- optical depth estimation
- celestial signal decomposition

These analytical tools allow the user to interpret astrophotographic data in terms of astrophysical characteristics such as nebular emission, stellar distributions, and galactic structures.

3. Results

Statistical analysis for the AstroGraph App was conducted using Microsoft Corporation **Microsoft Excel** (Redmond, Washington, USA) to calculate mean RGB values, standard deviations (SD), and error percentages across all sixteen colour standards.

To evaluate algorithm stability under extended observational conditions, **200 imaging samples** were analysed. The dataset included variations in optical distance, exposure settings, illumination intensity, and device alignment conditions.

3.1 Single Colour Standard Analysis

For the single **Red–Violet standard**, imaged under 200 varying observational conditions, the standardised dataset exhibited a **standard deviation of 3.05**, compared to **35.46 for the non-standardised dataset**.

This represents a **substantial reduction in variability**, demonstrating that brightness and colour standardisation effectively compensates for fluctuations in imaging parameters.

3.2 Multi-Colour Dataset Analysis

Across all **16 colour standards**, the standardised pixel data consistently showed reduced variability compared with the non-standardised measurements.

The **mean standard deviation decreased from 39.44 to 4.45**, while the **mean error percentage decreased from 69.59% to 44.78%**, indicating significantly improved reproducibility following colour standardisation.

Channel	Standardised		Non-standardised	
	SD	**Error %**	**SD**	**Error %**
Red	5.89	45.36	43.27	59.67
Green	4.53	42.71	39.44	68.41
Blue	2.99	46.26	31.15	80.70
Mean	**4.45**	**44.78**	**39.44**	**69.59**

Table 1 Multi-colour dataset (16 standards) for the AstroGraph App showing standard deviation (SD) and error percentage before and after brightness and colour standardisation

3.3 Statistical Power Estimation

Post-hoc statistical power estimation was performed for the dataset of **200 imaging conditions** using a significance level of **$\alpha = 0.05$**.

Based on the observed effect size between standardised and non-standardised datasets, the calculated statistical power exceeded **99% ($\beta \approx 0.01$)**.

This confirms that the dataset is sufficiently large to reliably detect improvements in colour reproducibility introduced by the AstroGraph standardisation algorithm.

3.4 Implications for Astrophotographic Analysis

The reduction in pixel variability achieved through the AstroGraph brightness and colour standardisation workflow enables more reliable quantitative interpretation of astrophotographic images. In particular, the improved reproducibility supports:

1. **Photon percentage estimation** for relative brightness analysis.
2. **Consistent RGB colour interpretation** across varying imaging conditions.
3. **Stable input data** for advanced analytical features such as Celestial Signal decomposition, morphological mapping, and stellar temperature estimation.

Overall, the results demonstrate that the AstroGraph App significantly enhances the reliability of smartphone- and telescope-based astrophotographic image analysis under variable observational conditions.

4. Discussion

4.1 Improvement in Image Reproducibility

The results obtained from the AstroGraph dataset demonstrate that brightness and colour standardisation substantially improves the reproducibility of astrophotographic image analysis [10, 12]. Across 200 imaging conditions, the standard deviation of RGB measurements decreased dramatically following standardisation. For the Red–Violet colour standard, variability was reduced from 35.46 to 3.05, indicating that the implemented algorithm effectively compensates for variations caused by illumination differences, optical alignment, and atmospheric transmission effects.

When extended to the complete dataset of sixteen colour standards, the average standard deviation decreased from 39.44 to 4.45, while the mean error percentage decreased from 69.59% to 44.78%. These reductions demonstrate that the AstroGraph standardisation workflow provides a stable numerical basis for analysing digital astrophotography. The results suggest that consistent brightness correction can significantly improve the reliability of pixel-level measurements, which are essential for subsequent astrophysical interpretation [39-41].

Furthermore, the large dataset used in this study provides strong statistical confidence in the findings. Post-hoc power analysis indicated statistical power exceeding 99%, confirming that the observed reductions in variability are unlikely to occur by chance. This statistical robustness supports the application of AstroGraph as a quantitative image analysis platform rather than solely a visualisation tool.

4.2 Relationship to Previous Studies (iSkyMatch → iAstroGraph → AstroGraph)

The results of the present study build upon earlier research investigating brightness standardisation in smartphone-based astrophotography systems [10, 30, 34]. The development of AstroGraph represents the third stage in a progressive research sequence designed to evaluate increasing dataset sizes and software capabilities [10, 12].

The first stage, implemented in the **iSkyMatch** system, analysed a dataset of approximately 50 imaging samples and demonstrated that brightness standardisation could significantly reduce RGB variability in mobile astrophotography [12]. That study provided initial evidence that smartphone-based imaging could produce reproducible colour measurements when appropriate correction algorithms were applied.

The second stage, developed through the **iAstroGraph** platform, expanded the dataset to approximately 100 imaging conditions and introduced additional astrophotographic analytical tools [10]. This stage confirmed that brightness correction and pixel-level analysis could be applied reliably across larger observational datasets, strengthening the statistical basis of the method.

The present study represents the third stage in this progression through the development of the cross-platform **AstroGraph** system. By analysing 200 imaging samples across sixteen colour standards, the study demonstrates that the colour standardisation algorithm remains stable and reproducible even when applied to substantially larger datasets. The gradual increase in dataset size—from 50 [12] to 100 [10] and finally 200 observations—illustrates the scalability of the analytical approach and supports the reliability of the underlying methodology.

4.3 Comparison with Existing Astronomical Software

Several established software tools are widely used for analysing astronomical imagery, including SAOImage DS9 [21], Aladin Sky Atlas [22], and Stellarium [23]. Each of these programs offers powerful capabilities within specific domains of astronomical analysis. For example, SAOImage DS9 provides advanced visualisation and manipulation of FITS datasets commonly used in professional observatories, while Aladin Sky Atlas integrates astronomical catalogues and sky surveys for data exploration [21, 22]. Stellarium primarily functions as a real-time sky simulation environment for educational and observational planning purposes [23].

Despite their strengths, these platforms generally focus on either desktop-based data processing or sky simulation [21-23] rather than real-time analysis of astrophotographic images captured in the field [18, 24]. In contrast, AstroGraph was designed to support both mobile and desktop environments, enabling users to analyse images directly on smartphones or tablets attached to telescopes. This capability allows astrophotographic measurements to be performed immediately during observations, rather than requiring subsequent post-processing on laboratory computers.

Another distinguishing feature of AstroGraph is its implementation of **Celestial Signal analysis** [42], which performs pixel-level decomposition to estimate contributions from nebulae, stellar sources, and galactic structures [43-47]. This type of real-time astrophysical interpretation is not commonly integrated within mobile astronomical imaging tools. As a result, AstroGraph provides a unique combination of portability and analytical capability that complements rather than replaces traditional desktop-based astronomy software.

4.4 Implications for Field Astronomy and Citizen Science

The availability of mobile astrophotography analysis tools has the potential to significantly broaden participation in astronomical research [46-49]. By enabling real-time analysis of telescope images using widely available mobile devices, AstroGraph lowers the technical barrier for observational astronomy [52, 53]. Amateur astronomers and educational institutions can perform quantitative image analysis without requiring specialised laboratory software or high-performance computing systems [54-57].

Such capabilities may also support citizen science initiatives, where distributed networks of observers contribute observational data for scientific analysis [58-60]. The ability to perform preliminary image analysis directly on mobile devices could allow participants to quickly identify astrophysical features of interest, such as nebular emission regions or galaxy morphology, before submitting datasets to collaborative research platforms [61].

For professional astronomers, the integration of mobile analysis tools may improve observational efficiency by enabling immediate feedback during field observations. Researchers can evaluate image quality, brightness distributions [62], and morphological features in real time [63], allowing adjustments to telescope alignment or exposure parameters during data acquisition.

4.5 Limitations and Future Development

Although the results demonstrate the effectiveness of the AstroGraph brightness standardisation algorithm [10, 12], several limitations should be considered. The present study primarily evaluated colour reproducibility using controlled colour standards rather than a broad set of astronomical objects. Future studies could expand the dataset to include a wider variety of astrophysical targets such as emission nebulae, planetary nebulae, star clusters, and galaxies [64, 65].

In addition, further development of the AstroGraph platform may incorporate additional photometric calibration features, spectral analysis modules [37, 46], and integration with astronomical databases [55]. These enhancements could enable more detailed astrophysical interpretation while maintaining the portability and accessibility of the mobile platform.

Finally, future studies may investigate the integration of machine learning algorithms for automated object classification and feature detection, which could further enhance the analytical capabilities of cross-platform astronomical imaging systems.

5. Conclusion

The development of the AstroGraph platform represents the third stage in a progressive research sequence aimed at improving the reliability and accessibility of smartphone-based astrophotographic image analysis. Earlier investigations using the iSkyMatch system demonstrated that brightness standardisation could substantially reduce RGB variability in mobile astrophotography using a dataset of approximately 50 imaging conditions [12]. This initial proof-of-concept study established that colour correction algorithms could significantly improve the reproducibility of digital astronomical images captured with mobile devices [15, 28]. Subsequent research using the iAstroGraph platform expanded the dataset to approximately 100 imaging conditions [10] and introduced additional astrophotographic analysis tools, confirming that brightness correction and pixel-level measurement techniques remained stable across larger observational datasets [30, 34]. Building upon these foundations, the present study evaluated the cross-platform AstroGraph system using an expanded dataset of 200 imaging samples across sixteen colour standards. The results demonstrate that brightness and colour standardisation significantly reduce RGB variability and error rates, with mean standard deviation decreasing from 39.44 to 4.45 and statistical power exceeding 99%. In addition to improving measurement reproducibility, AstroGraph introduces real-time celestial signal analysis, morphological mapping, and cross-platform functionality that enable astronomical image analysis directly on mobile devices as well as desktop systems. Collectively, the progression from iSkyMatch [12] to iAstroGraph [10] and finally to AstroGraph illustrates the scalability and robustness of the underlying methodology, demonstrating that mobile and cross-platform software tools [24] can support reliable astrophotographic measurements while expanding access to quantitative astronomical analysis for professional researchers, educators, and amateur astronomers [10, 12, 25, 27].

6. Author Declarations and Disclaimers

6.1 Software and Methodology Disclaimer: The cross-platform AstroGraph smartphone application is designed as a research and educational tool for analysing astrophotographic images, including RGB colour analysis, brightness standardisation, photon-percentage estimation, and sky-background interpretation. The analytical outputs generated by the software are intended for informational and exploratory purposes only and should not be interpreted as definitive astronomical measurements. Users are encouraged to validate results using established astronomical instrumentation and methodologies where precise quantitative measurements are required.

6.2 Funding: The development of the AstroGraph App and the preparation of this manuscript were self-funded by the author. No external funding sources supported this work.

6.3 Privacy Notice: The AstroGraph 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.

6.4 Conflict of Interest: The author is the developer of the AstroGraph 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.

6.5 Author Contributions: The author conceived the study, developed the AstroGraph application framework, designed the experimental methodology, performed the image analysis and statistical evaluation, and prepared the manuscript.

6.6 Data Availability: The datasets generated and analysed during this study are available from the corresponding author upon reasonable request.

References

1. Walsh LJ, Shakibaie F (2007) Ultraviolet-induced fluorescence:shedding new light on dental biofilms and dental caries. Australas Dent Prac 18(6): 56-60
2. Shakibaie F, Walsh LJ (2012) Differential Reflectometry versus tactile sense detection of subgingival calculus in dentistry. J Biomed Opt 17(10):106017. doi:10.1117/1.JBO.17.10.106017
3. Walsh LJ, Shakibaie F (2014) Debridement endpoints from subgingival calculus detection. Australas Dent Prac 24:22-23
4. Shakibaie F, Law K, Walsh LJ (2019) Improved detection of subgingival calculus by laser fluorescence over differential reflectometry. Lasers Med Sci 34(9):1807-1811. doi:10.1007/s10103-019-02777-6
5. Bird PS, Shakibaie F, Gemmell E, Polak B, Seymour GJ (2001) Immune response to Bacteroides forsythus in a murine model. Oral Microbiol Immunol 16(5):311-315. doi:10.1034/j.1399-302x.2001.016005311.x
6. Shakibaie F, Diklic S, Walsh LJ (2002) An assessment of changes in dentine permeability following irradiation with a pulsed Erbium:YAG laser. Periodontology 23(1):4-7
7. Tody D (1986) The IRAF data reduction and analysis system. Proc SPIE 0627, Instrumentation in Astronomy VI, 627:733-748. doi:10.1117/12.968154
8. Shakibaie F, Gemmell E, Bird PS (2001) A mouse model to study pathogenicity of Bacteroides forsythus. Periodontology 22(1):5-8
9. Gonzalez RC (2009) Digital image processing. Pearson Education India
10. Shakibaie F (2027) Embark on Celestial Adventures: Unveiling the Marvels of the Night Sky with the iAstroGraph App, Your Smartphone's Ultimate Astrophotography Companion. Int Dig J Tele-Opt Ser 1(1):10-20
11. Carroll BW, Ostlie DA (2017) An introduction to modern astrophysics (2nd ed). Cambridge University Press
12. Shakibaie F (2027) Unlocking the wonders of the night sky with iSkyMatch App: A smartphone-based astrophotography companion. Int Dig J Tele-Opt Ser 1(1):1-9
13. Blanton MR, Dalcanton J, Eisenstein D, Loveday J, Strauss MA, SubbaRao M, Weinberg DH, Anderson Jr JE, Annis J, Bahcall NA, Bernardi

M, Brinkmann J, Brunner RJ, Burles S, Carey L, Castander FJ, Connolly AJ, Csabai I, Doi M, Finkbeiner D, Friedman S, Frieman JA, Fukugita M, Gunn JE, Hennessy GS, Hindsley RB, Hogg DW, Ichikawa T, Ivezić Ž, Kent S, Knapp GR, Lamb DQ, Leger RF, Long DC, Lupton RH, McKay TA, Meiksin A, Merelli A, Munn JA, Narayanan V, Newcomb M, Nichol RC, Okamura S, Owen R, Pier JR, Pope A, Postman M, Quinn T, Rockosi CM, Schlegel DJ, Schneider DP, Shimasaku K, Siegmund WA, Smee S, Snir Y, Stoughton C, Stubbs C, Szalay AS, Szokoly GP, Thakar AR, Tremonti C, Tucker DL, Uomoto A, Berk DV, Vogeley MS, Waddell P, Yanny B, Yasuda N, York DG (2001) The luminosity function of galaxies in SDSS commissioning data. Astron J 121(5):2358-2380. doi:10.1086/320405

14. Bevington PR, Robinson DK (1969) Data reduction and error analysis for the physical sciences McGraw-Hill. New York 19692:235-242
15. Shakibaie F (2023) Sources of astronomical information for iSkyMatch App. LinkedIn Website: https://www.linkedin.com/pulse/sources-astronomical-information-iskymatch-app-tele-optic-services-wdnqc
16. Kervella P, Thévenin F, Di Folco E, Segransan D (2004) The angular sizes of dwarf stars and subgiants - Surface brightness relations calibrated by interferometry. Astron Astrophys 426(1):297-307. doi:10.1051/0004-6361:20035930
17. Shakibaie F (2027) Manual instruction for iOralCam: SmartPhone application (version 1.2) for detection and processing of tooth surfaces using intra-oral cameras. Int Dig J Tele-Opt Ser 1(2):1-8
18. Ambrosino F, Cretaro P, Meddi F, Rossi C, Sclavi S, Bruni I (2016) The latest version of SiFAP: beyond microsecond time scale photometry of variable objects. J Astron Instrum 5(03):1650005. doi:10.1142/S2251171716500057
19. Shakibaie F (2011) Detection of subgingival calculus by optical methods. The University of Queensland, PhD Thesis Pg:1-306
20. Ambrosino F, Meddi F, Nesci R, Rossi C, Sclavi S, Bruni I (2013) SiFAP: a simple sub-millisecond astronomical photometer. J Astron Instrum 2(01):1350006. (6 Pages) doi:10.1142/S2251171713500062
21. Mandal AM (2019) Measurements of 60 double star systems using a small telescope and four different methods. Meas 15(1):193-202
22. Petrov GT (2012) Linux astronomical software. Book of abstracts Pg:1-13
23. Zotti G, Hoffmann SM, Wolf A, Chéreau F, Chéreau G (2021) The simulated sky: Stellarium for cultural astronomy research. arXiv preprint arXiv:2104.01019
24. Shakibaie F (2027) SmartPhone OralCam App (Version 1.0) in molecular, colour, and shade detection processing of tooth surfaces using intra-oral cameras. Int Dig J Tele-Opt Ser 1(2):9-17
25. Banks PM, Williamson PR, Raitt WJ (1983) Space-shuttle glow observations. Geophys Res Lett 10(2):118-121. doi:10.1029/GL010i002p00118
26. Shakibaie F, Walsh LJ (2015) Performance differences in the detection of subgingival calculus by laser fluorescence devices. Lasers Med Sci 30(9):2281-2286. doi:10.1007/s10103-015-1808-4
27. Bone N (1999) Observing Meteors, Comets, Supernovae and other transient phenomena: And other transient phenomena. Springer Science & Business Media
28. Shakibaie F (2023) Unlocking the wonders of the night sky with iSkyMatch App: Your smartphone's astrophotography companion. LinkedIn Article Website: https://www.linkedin.com/pulse/unlocking-wonders-night-sky-iskymatch-app-your-smartphones-x1uyc?trk=article-ssr-frontend-pulse_little-text-block
29. Reynolds MD (2023) Binocular stargazing. Rowman & Littlefield+ ORM
30. Shakibaie F (2023) Embark on celestial adventures: Unveiling the marvels of the night sky with the iAstroGraph App, your smartphone's ultimate astrophotography companion. LinkedIn Article Website: https://www.linkedin.com/pulse/embark-celestial-adventures-unveiling-marvels-night-awtgc/
31. Hart J, van Harmelen J, Hovey G, Freeman KC, Peterson BA, Axelrod TS, Quinn PJ, Rodgers AW, Allsman RA, Alcock C, Bennett DP, Cook KH, Griest K, Marshall SL, Pratt MR, Stubbs CW, Sutherland W (1996) The telescope system of the MACHO program. Publ Astron Soc Pac 108(720): 220-222. doi:10.1086/133713
32. Shakibaie F, Walsh LJ (2016) Violet and blue light-induced green fluorescence emissions from dental calculus: a new approach to dental diagnosis. Intern Dent – African Edition 6(6):33-39
33. Karachentsev ID, Karachentseva VE, Huchtmeier WK, Makarov DI (2004) A catalog of

neighboring galaxies. Astron J 127(4):2031-2068. doi:10.1086/382905

34. Shakibaie F (2023) Sources of astronomical information for iAstroGraph App. LinkedIn Article Website: https://www.linkedin.com/pulse/sources-astronomical-information-iastrograph-app-jqyic/
35. Chen H, Myers PC, Ladd EF, Wood DOS (1995) Bolometric temperature and young stars in the Taurus and Ophiuchus complexes. Astrophys J 445(1):377-392
36. Shakibaie F, Walsh LJ (2019) Fluorescence imaging of dental restorations using the VistaCam intra-oral camera. Aust J Forensic Sci 51(1):3-11. doi:10.1080/00450618.2017.1304991
37. Gray DF (1994) Spectral line-depth ratios as temperature indicators for cool stars. Publ Astron Soc Pac 106(706):1248-1257. doi:10.1086/133502
38. Arp HC (1958) The Hertzsprung-Russell diagram. In: Astrophysics II: Stellar Structure/Astrophysik II: Sternaufbau, Encyclopedia of Physics / Handbuch der Physik, Springer, Berlin, Heidelberg. 11(51):75-133. doi:10.1007/978-3-642-45908-5_2
39. Shakibaie F, Walsh LJ (2015) Effect of oral fluids on dental caries detection by the VistaCam. Clin Exp Dent Res 1(2):74-79. doi:10.1002/cre2.13
40. Baliunas S, Jastrow R (1990) Evidence for long-term brightness changes of solar-type stars. Nature348(6301):520-523. doi:10.1038/348520a0
41. Shakibaie F, Walsh LJ (2015) DIAGNOdent Pen versus tactile sense for detection of subgingival calculus: an in vitro study. Clin Exp Dent Res 1(1):26-31. doi:10.1002/cre2.5
42. Ambrosino F, Meddi F (2018) Chapter 4 – Photon counting for studying faint astronomical variable signals in optical band, In “Photon counting – Fundamentals and applications”, edited by Nikolay Britun and Anton Nikiforov; InTechOpen Pg:81-104. doi:10.5772/intechopen.71072
43. Shakibaie F, Walsh LJ (2014) Surface area and volume determination of subgingival calculus using laser fluorescence. Lasers Med Sci 29(2):519-524. doi:10.1007/s10103-012-1242-9
44. Ha WN, Shakibaie F, Kahler B, Walsh LJ (2016) Deconvolution of the particle size distribution of ProRoot MTA and MTA Angelus. Acta Biomater Odontol Scand 2(1):7-11. doi:10.3109/23337931.2015.1129611
45. Shakibaie F, Lamard L, Rubinsztein-Dunlop H, Walsh LJ (2018) Chapter 10 - Application of fluorescence spectroscopy for microbial detection to enhance clinical investigations, In “Photon Counting-Fundamentals and Applications” by Britun N and Nikiforov A, InTechOpen Pg:225-242. doi:10.5772/intechopen.73616
46. Filippenko AV (1982) The importance of atmospheric differential refraction in spectrophotometry. Publ Astron Soc Pacific 94(560):715-721. doi:10.1086/131052
47. Shakibaie F, George R, Walsh LJ (2011) Applications of laser induced fluorescence in dentistry. Intern J Dent Clin 3(3):38-44
48. Caucci L, Ding Y, Barrett HH (2018) Chapter 5 – Computational methods for photon-counting and photon-processing detectors, In “Photon counting – Fundamentals and applications”, edited by Nikolay Britun and Anton Nikiforov; InTechOpen Pg:105-124. doi:10.5772/intechopen.72151
49. Youker RT (2018) Chapter 12 – Detectors for super-resolution & single-molecule fluorescence microscopies, In “Photon counting – Fundamentals and applications”, edited by Nikolay Britun and Anton Nikiforov; InTechOpen Pg:261-285. doi:10.5772/intechopen.71943
50. Caucci L, Barrett HH (2012) Objective assessment of image quality. V. Photon-counting detectors and list-mode data. J Opt Soc Am A 29(6):1003-1016. doi:10.1364/JOSAA.29.001003
51. Dautet H, Deschamps P, Dion B, MacGregor AD, MacSween D, McIntyre RJ, Trottier C, Webb PP (1993) Photon counting techniques with silicon avalanche photodiodes. Appl Opt 32(21):3894-3900. doi:10.1364/AO.32.003894
52. Steele IA, Jameson RF (1995) Optical spectroscopy of low-mass stars and brown dwarfs in the pleiades. Mon Not R Astron Soc 272(3):630-646. doi:10.1093/mnras/272.3.630
53. Russell HN (1914) Relations between the spectra and other characteristics of the stars. Popul Astron 22:331-351
54. Shakibaie F, Walsh LJ (2017) KEY3 laser treatment applications in oral and maxillofacial surgery. J Head Neck Spine Surg 1(5):555574. doi:10.19080/JHNSS.2017.01.555574
55. Berk DEV, Richards GT, Bauer A, Strauss MA, Schneider DP, Heckman TM, York DG, Hall PB, Fan X, Knapp GR, Anderson SF, Annis J, Bahcall NA, Bernardi M, Briggs JW, Brinkmann J, Brunner R, Burles S, Carey L, Castander FJ, Connolly AJ, Crocker JH, Csabai I, Doi M, Finkbeiner D, Friedman S, Frieman JA, Fukugita M, Gunn JE, Hennessy GS, Ivezić Ž, Kent S, Kunszt PZ, Lamb DQ, R. Leger RF, Long DC, Loveday J, Lupton RH, Meiksin A, Merelli A, Munn JA, Newberg HJ, Newcomb M, Nichol

RC, Owen R, Pier JR, Pope A, Rockosi CM, Schlegel DJ, Siegmund WA, Smee S, Snir Y, Stoughton C, Stubbs C, SubbaRao M, Szalay AS, Szokoly GP, Tremonti C, Uomoto A, Waddell P, Yanny B, Zheng W (2001) Composite quasar spectra from the sloan digital sky survey. Astron J 122(2):549-564. doi:10.1086/321167

56. Shakibaie F, Walsh LJ (2016) Laser fluorescence detection of subgingival calculus using the DIAGNOdent Classic versus periodontal probing. Lasers Med Sci 31(8):1621-1626. doi:10.1007/s10103-016-2027-3
57. Schmidt BP, Kirshner RP, Eastman RG, Phillips MM, Suntzeff NB, Hamuy M, Maza J, Avilés R (1994) The distances to five type~ II supernovae using the expanding photosphere method, and the value of H_0. Pg:1-17. doi:10.48550/arXiv.astro-ph/9407098
58. Shakibaie F, Walsh LJ (2016) Dental calculus detection using the VistaCam. Clin Exp Dent Res 2(3):226-229. doi:10.1002/cre2.42
59. Kervella P, Fouqué P (2008) The angular sizes of dwarf stars and subgiants – Non-linear surface brightness relations in BVR(c)I(c) from interferometry. Astron Astrophys 491(3):855-858. doi:10.1051/0004-6361:200810317
60. Shakibaie F, Walsh LJ (2016) Violet and blue light-induced green fluorescence emissions from dental caries. Aust Dent J 61(4):464-468. doi:10.1111/adj.12414
61. Unsöld A, Baschek B (2013) The new cosmos: an introduction to astronomy and astrophysics, Springer Science & Business Media
62. Lockwood GW, Skiff BA, Baliunas SL, Radick RR (1992) Long-term solar brightness changes estimated from a survey of sun-like stars. Nature 360(6405):653-655. doi:10.1038/360653a0
63. Christensen-Dalsgaard J (1988) A Hertzsprung-Russell diagram for stellar oscillations. Symposium - International Astronomical Union, Volume 123: Advances In Hello- and Asteroseismology, Cambridge University Press 123:295-298. doi:10.1017/S0074180900158279
64. Doom C, De Greve JP, De Loore C (1986) Stellar evolution in the upper Hertzsprung-Russell diagram. Astrophys J 303(1):136-145
65. Shakibaie F (2027) SkyRadar: A cross-platform grayscale radar meteorology and astrograph analysis engine for atmospheric and astronomical imaging. Int Dig J Tele-Opt Ser 1(1):36-49