Information paper: [[1]](#footnote-1) ENG17-3.1.1.4

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM X ENG **□** PAP **□** Input

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Agenda item [[2]](#footnote-2) n.n

Technical Domain / Task Number 2 …………………………………

Author(s) / Submitter(s) Chungjin Lee / Korea Institute of Aids to Navigation

Introduction of the Luminous Intensity Measurement System

Using Drone

# Summary

This information document introduces a case study in South Korea to measure and analyze the luminous intensity of visual aids (lanterns) installed at sea using drones.

# Background

In Korea, pre-use inspections, regular inspections, and change inspections are conducted to meet the standards for use of lanterns, and measurements are conducted in indoor or outdoor (open-air) environments to measure luminous intensity.

1. Classification of lantern

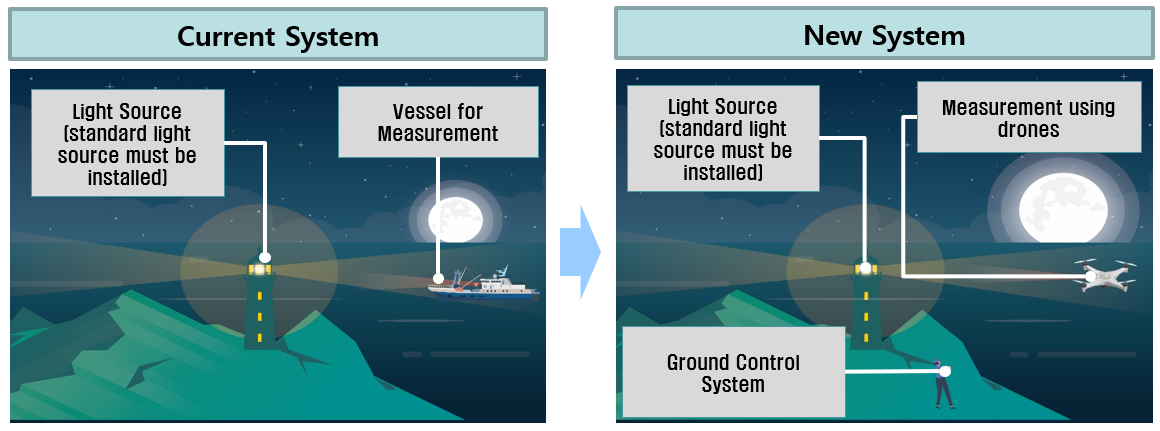
|  |  |  |  |
| --- | --- | --- | --- |
| **Classification** | **Inner diameter of the lens** | **Height of the lens** | **Method of measuring the luminous intensity** |
| **Large class** | 750mm or more | 1,250mm or more | Outdoor  measurement |
| **Middle class** | 300mm ~ 750mm | 433mm ~ 1,250mm | Indoor and outdoor  measurements |
| **Small class** | Less than 300mm | Less than 433mm | Indoor  measurement |

Lanterns are classified according to the inner diameter and height of the lens as shown in Table 1, and can be measured in an indoor (dark room) or outdoor (open-air) environments. Small-class lanterns with small size can be disassembled on site and be accurately measured using an indoor light distribution tester, but middle-class and large-class lanterns are difficult to measure because they are difficult to install and disassemble on site. Therefore, in Korea, luminance meter equipment is currently installed on the ground or on a measurement ship (marine environment) to perform measurements as an outdoor (open-air) measurement method.

However, the measurement method using a measurement ship is in need of improvement due to budget problems, safety problems, and the analysis accuracy problems caused by waves that arise while operating the measurement ship. To solve these problems, the methods to conveniently and accurately measure using drone instead of using measurement ship are being researched.

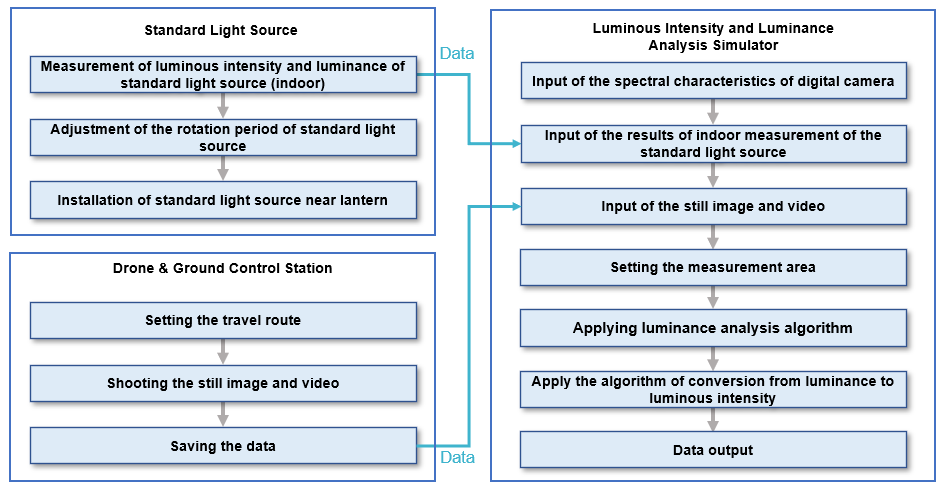
# Development of the drone-based aton photometry equipment

This research is a project that will be conducted for a total of three years from 2022 to 2024, and the second year of research is currently underway. The goal of this project is to improve the measurement system using existing measurement ships into an inspection system using drones, as shown in Figure 1 below.



*Figure 1 Development of the drone-based AtoN photometry equipment*

The measurement method is shown in Figure 2 below. To measure the luminous intensity in an outdoor (open-air) environment, a standard light source must be used, and luminous intensity and luminance data measured in advance in the indoors must be available.

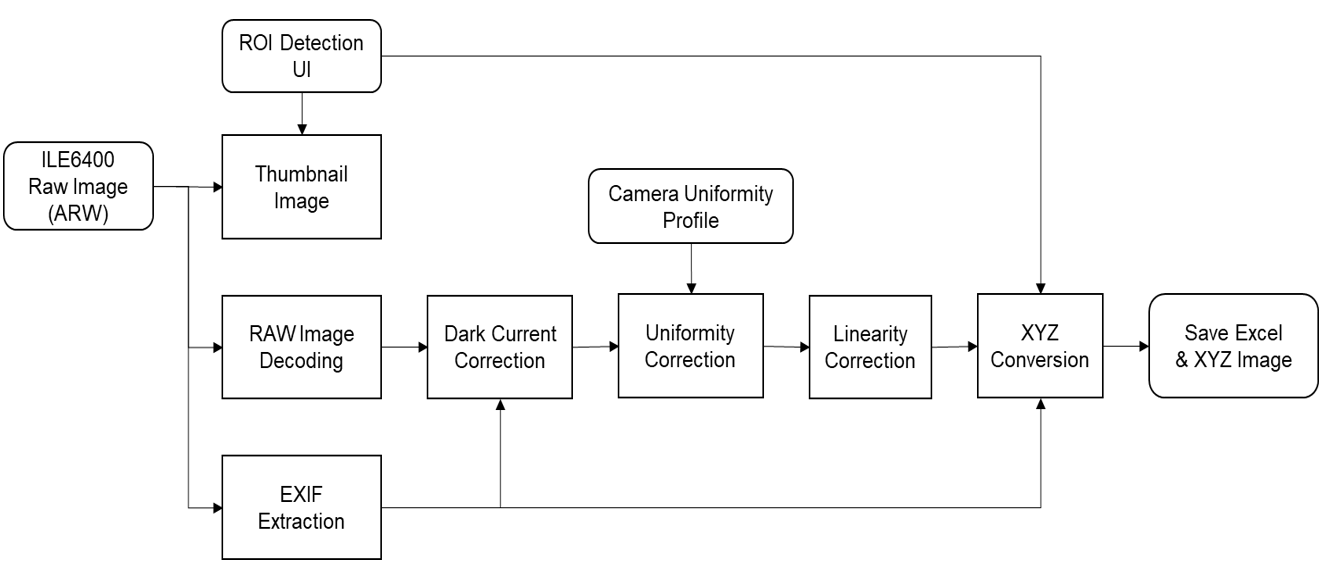


*Figure 2 Measurement method*

In the field, a standard light source is installed near the lantern to be measured, and a drone is used to photograph both the standard light source and the lantern. The data obtained in this way is being developed into a structure that can be analyzed in a luminous intensity and luminance analysis simulator.

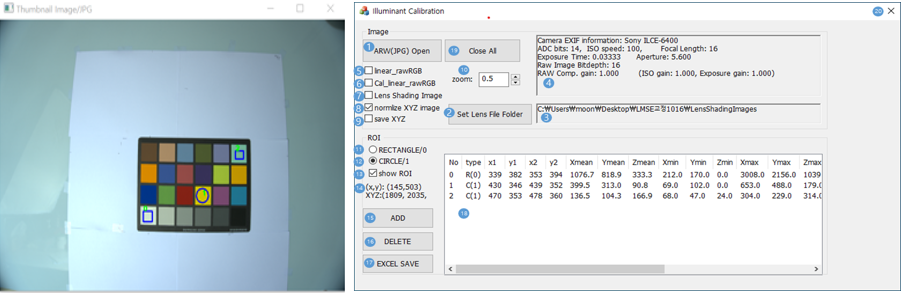
## Luminance analysis algorithm

The luminance analysis algorithm developed to date is shown in Figure 3. This algorithm uses still images (raw files) from digital cameras as input data. Using the input still images, dark current correction, uniformity correction, and linearity correction are performed from the camera image sensor and lens to remove noise, and the value corresponding to luminance can be obtained using XYZ conversion.



*Figure 3 Luminance analysis algorithm*

Based on algorithm above, a simulator was created as shown in Figure 4. When the area to be analyzed is selected from a still image, the maximum, minimum, average luminance of that area are derived.

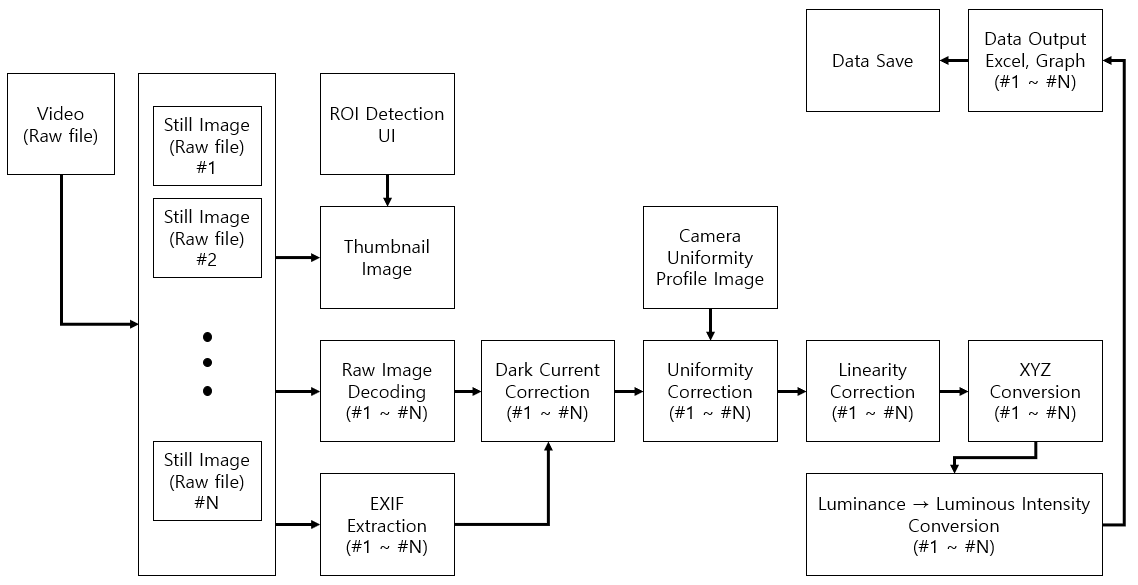


*Figure 4 Luminance analysis Simulator*

The performance of the algorithm was compared by measuring at the same position and angle as a digital camera (Sony ILCE6400) using a Minolta CS-1000 luminance meter equipment. As a result, it was confirmed that an average error of 2.58% occurred in 24 natural colors, and an average error of 0.74% occurred in 6 gray colors regarding luminance.

## Luminance analysis algorithm

Since the light source in a lighthouse rotates, it has the characteristics that its luminous intensity and luminance continuously change over time. A video-based luminous intensity measurement algorithm to analyze luminous intensity and luminance over time is being designed.



*Figure 5 Video-based luminous intensity and luminance analysis algorithm*

Figure 5 shows an algorithm that can analyze luminous intensity and luminance using video data as input. This is a method of analyzing the optical characteristics of each frame by scaling video captured with a camera mounted on a drone at regular intervals. If the area to be analyzed is selected in the main frame, the Motion Vector position tracking algorithm can be applied to track the light source in multiple frames and analyze the luminous intensity and luminance characteristics of the area.

The video data used for measurement must be used as a raw file. Therefore, the method to adjust the time and scaling interval of the video considering the size of the data is being developed, and are implementing a function that can store and graph the size of luminous intensity and luminance over time.

## The method of conversion for luminous intensity and luminance

Since it is in general impossible to measure the luminous intensity of a light source in an outdoor (open-air) environment, an anomalous method is used. Basically, it uses a separate light source called a standard light source and uses proportional values to derive the luminous intensity of the lantern to be measured.

1. Parameters for the conversion of luminous intensity and luminance

|  |  |
| --- | --- |
| **Parameter** | **Description** |
|  | Luminance of a standard light source measured indoors **(measured value)** |
|  | Luminous intensity of a standard light source measured indoors **(measured value)** |
|  | Luminance of a standard light source measured outdoors (in open-air) **(measured value)** |
|  | Rate of change according to environmental changes in standard light source **(analysis value)** |
|  | Luminous intensity of standard light source outdoors (in open-air) **(analysis value)** |
|  | Luminance of the lantern to be measured outdoors (in open-air) **(measured value)** |
|  | Luminous intensity of the lantern to be measured outdoors (in open-air) **(measured value)** |

Use the parameters in Table 2 above to calculate the luminous intensity of the lantern to be measured.

First, in order to obtain the luminous intensity of the lantern to be measured, the luminous intensity of a standard light source outdoors (in open-air) is required. This can be calculated using the equations below.

The luminous intensity of the lantern to be measured can be derived using the proportional equation below.

# Future works

Currently, the video-based luminous intensity and luminance measurement equipment (drones) and analysis programs are being developed, and it is planned to analyze how much error occurs compared to existing measurement methods in actual sites at the end of 2023 or 2024. The research will also be continuously conducted to increase measurement efficiency and performance.

# Action requested of the Committee

The Committee is requested to:

1. This document is an information paper and was written simply for the purpose of sharing information.
2. We plan to resubmit and share the research results with the ENG 18 or ENG 19 committee, and please discuss how they can be reflected in IALA guidelines and recommendation.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)