Luminance and non-uniformity changes in primary monitors over the 4-year period of QA measurements.

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INTRODUCTION

Optimal performance of the primary monitors depends on the Digital Imaging and Communication in Medicine Grayscale Standard Display Function (DICOM GSDF) calibration of the monitor and on a number of Primary Monitor's parameters such as minimum and maximum luminance, luminance uniformity and ambient conditions in the reading room.

This work presents the results of the quality control measurements of several Primary Monitor characteristics in four consecutive years.

MATERIALS

18 primary monitors (**Barco, MDCC-6130**) which were continuously in service for 4 years (2016-2019).

RaySafe Solo Light photometer was used to measure the luminance and illuminance values.

METHOD

Maximum luminance (L_{max}) was measured using TG18-LN18 test pattern:

The annual changes in L_{max} were calculated for each tested monitor. All monitors were calibrated for L_{max} of 400 cd/m^2

Monitor's non-uniformity
TG18UNL80 test pattern was used to verify the monitors **Maximum Luminance Deviation (MLD)**. Luminance values were measured at five locations on the diagnostic display: the center and at four corners. The MLD of a display was calculated using the following equation:
MLD (%) = 200 × $(L_2-L_1)/(L_2+L_1)$ (1), where L_2 is the highest recorded luminance, and L_1 is the lowest recorded luminance regardless of the location on the display

RESULTS

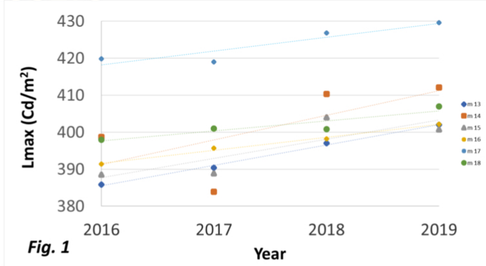

Fig. 1

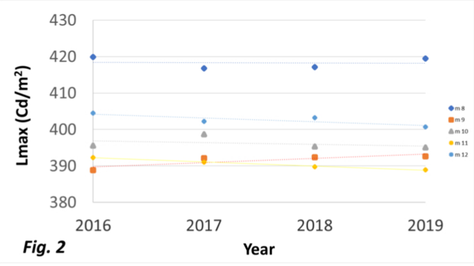

Fig. 2

Figures 1,2 and 3 present the results of annual measurements of the maximum luminance (L_{max}) in years: 2016-2019. All monitors are automatically calibrated for L_{max}= 400 cd/m^2. Six monitors out of 18, showed an increase of L_{max} during the tested period of four years (Fig.1). Five monitors did not show any statistically significant change of L_{max} (Fig. 2) and 7 monitors showed a decrease of L_{max}, during the period of four years (Fig.3).

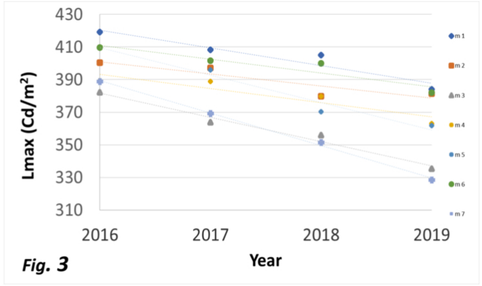

Fig. 3

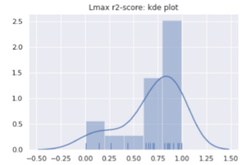

Fig. 4

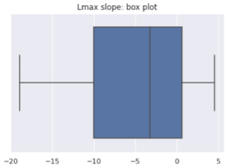

Fig. 5

The goodness of fit of a linear regression model is estimated by an r^2 -score. The plot on the left (Fig.4) illustrates a distribution of r^2 -scores for the L_{max} measurements. For the box plot on the right (Fig.5), we restrict to a subset of monitors where the fit is good: r^2 -score >= 0.5. Computations for the L_{max} observations do not detect any outliers, but the L_{max} slopes of a couple of monitors are close to the bounds of the 95% confidence interval.

Fig 6 presents the MLD measurement results performed in years 2016-2019. All tested monitors showed an increase in non-uniformity over 4 years. All tested PDMs have uniformity value less than 19.8%, which is well below the PM QA standard of 30%.

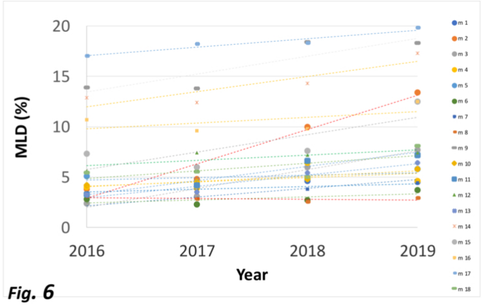

Fig. 6

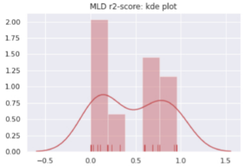

Fig. 7

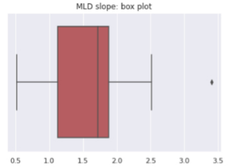

Fig. 8

The plot on the left (Fig. 7) illustrates a distribution of r^2 -scores for the MLD measurements. For the box plot on the right (Fig.8), we also restrict to a subset of monitors where the fit is good: r^2 -score >= 0.5. The isolated point in this figure corresponds to an outlier monitor which has an MLD slope that is too steep compared to the other monitors.

CONCLUSIONS

In this poster and in our previous publications it was shown that monitors luminance values can change at any direction in one-year time due to usage time and the multiple monitor calibrations. The findings of this work show that during the period of 4 years, all tested primary monitors showed the expected change of L_{max} and the increase of display's MLD values. Tracking changes of the display's L_{max} and MLD values with a QA program can help to predict the expected time of the primary monitor replacement.

ACKNOWLEDGEMENTS

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