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Evaluation of visual characteristics of image perception in avionics

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Abstract. The task is being studied to evaluate the amount of quality to perceive the picture elements being projected on LCD screens of modern on-board visual means to display the information. A mean to display information is a multi-functional colorful indicator. The display itself (the frame being displayed) is a sign and symbol information. The symbol perception of different angle sizes is being studied. The families of probability characteristics have been received which characterize with numbers the quality of symbol perception being displayed under different screen resolutions.

1. Introduction

In modern aviation the primary information display mean is multi-functional display unit (MFDU) [1, 2]. They give pilots piloting and navigation information which is necessary in each moment of the flight time. If necessary for the pilot the MFDU may give the secondary information data.

Apart from the MFDU the information display equipment and the on-board system control there are some remote control units on the airplane board. All together such on-board equipment in the aircraft cabin is a system of information display [3, 4]. In the aviation item designing sometimes they say information and control field instead of the display information system.

Indicative element which is a part of the on-board information display means is a liquid crystal matrix. The primary exploitation properties of an MFDU which defines its characteristics of picture color reproduction are [5, 6]:

- brightness and its (colorful) contrast of a picture;
- vertical and horizontal resolutions of the matrix in pixels;
- the limit values of the perception angles for the picture with preservation of the picture being displayed;
- coefficients values of diffuse and mirror reflection of the screen;
- the angle sizes of colorful symbols and signs being displayed.

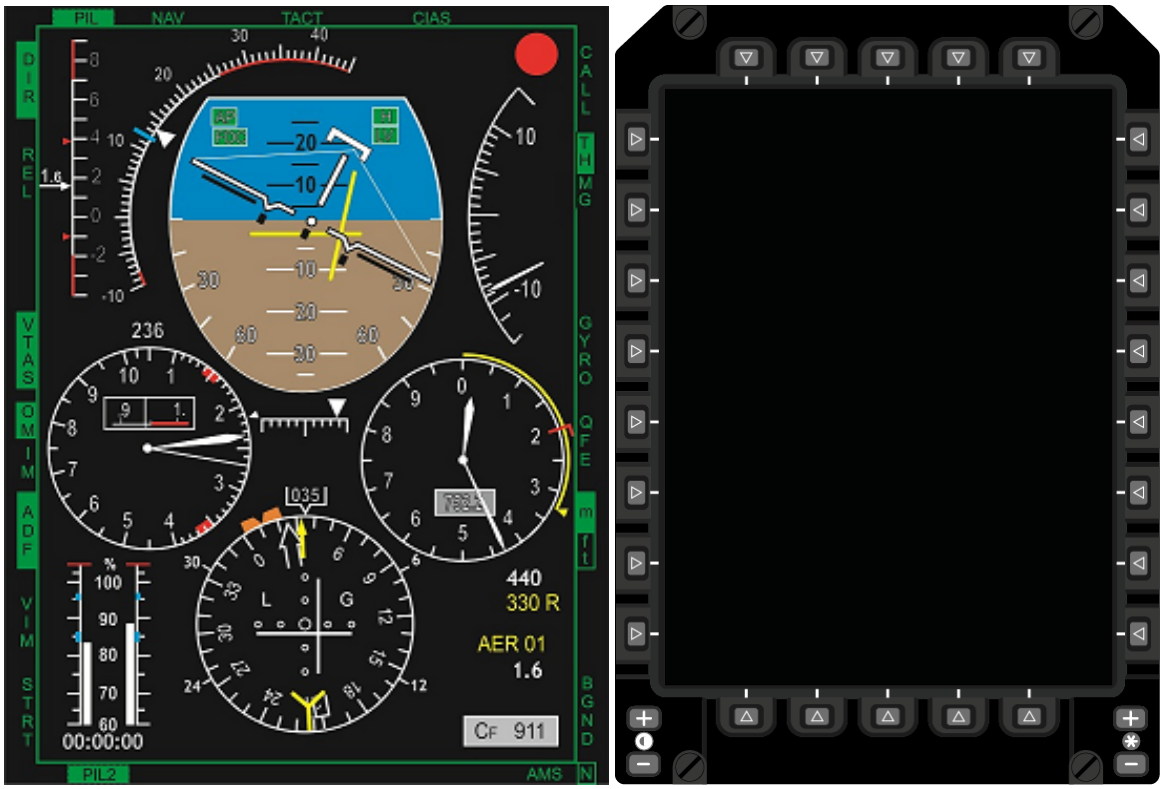
After several researches and according to the existing norm technical documentation which is valid now in the aviation item designing without any fault the pilot may perceive from the MFDU screen the

symbols of the size 30 and more angle minutes if the brightness contrast is more than 0.5 [7, 8]. If they reduce the size of the on-board screens and the saturation of the indicative frame increase the MFDU designer needs to display the symbols of lower size. That why it is an actual problem to evaluate visual characteristics of display perception from the MFDU screen with some symbol elements of lower geometric size.

2. The composition of avionics indicative frame

According to the type of the on-board indicator the liquid crystal display (LCD) panel may display pictures of different resolutions. In practice this is a popular thing the screen with resolution of 768x1024 pixels with maximum amount of shades of each primary color (red, green, blue), which is 256 [9, 10].

To display the information with an MFDU means to divide the general information field (indicative frame) in several zones with some information for the crew (figure 1, a). And also with MFDU buttons you may change the displaying items and of course you may change the piloting and navigation parameters being displayed (figure 1, b).



a) b)

Figure 1. MFDU indicator: a) an avionics indication frame (example), b) indicator face panel.

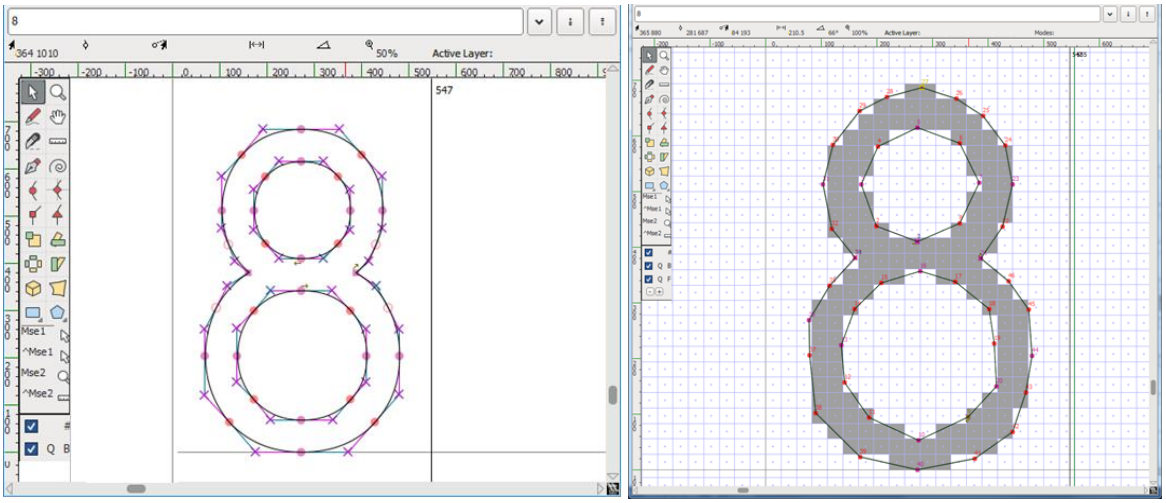
Indicative frame structure is a set of elements made with graphics (exterior) which are corresponding to analog items which can be easily seen and understood. The indicative frame displays graphical elements of line and circular scales; graphical primitives (lines, circles, arcs, arrows and other); detectors (numerical parameters, changing its value during the aircraft flight); letter symbols of alphabet, numbers, special configuration symbols and other.

3. Indicative frame creation software

All graphical elements being displayed on the MFDU screen are made with software application in automatized working place of avionics designer.

The application software is used to create interactively some graphical elements and its save on the personal computer (PC) disc which are downloaded to the MFDU as library components. An example

of work window interface of the application software where the avionics designer creates the symbol exterior of number eight (vector format of data) is given in figure 2, a. Vector format of graphical elements which are used for displaying modes where the picture turns are permitted (for example the mode of unification of graphical picture and digital map of location in the flight zone) or scaling (size changing) of the picture. The picture must be turned when the aircraft has turned. To display the data with vector format permits to turn the picture or its scaling without significant form discrepancy of graphical symbols being displayed.



a) b)

Figure 2. Work window interface of avionics software application:
a) vector format, b) raster format of data display (the number 8 is used as an example).

For static elements display the raster format is the most popular one to preserve and display data. An example of number eight in the application software in the raster format is given in the figure 2, b. The raster inscription is a set of pixels located in the fixed net nodes and is a bit picture. Vector format is a curve line contours described with mathematical formula. So vector format is a set of lines which defines the tops (the beginning and end of lines) or support points which are connected with small lines. The looped figures made so is a contour of signs being displayed on the MFDU screen.

The functional software to process the values of piloting and navigation parameters which are received by the MFDU in on-board interface which forms the general indicative frame from the library components of graphical elements.

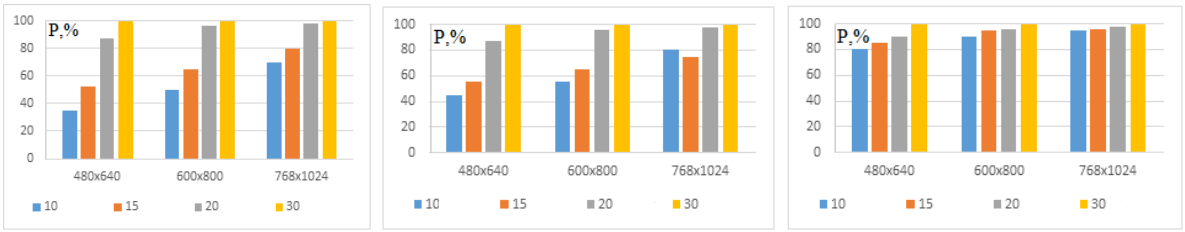
4. Symbol perception evaluation with small angle sizes

An experiment to evaluate visual characteristics of perception quality of indicative frame in avionics which contains symbols of different angle size included two stages:

- stage one was to research the resolution factor of an LCD (640x480, 800x600, 1024x768 pixels) for the visual perception of signs of different size (10, 15, 20 and 30 angle minutes) with fixed value of picture brightness contrast of 0.5 with color changing of displayed inscriptions (white, red, yellow, green, blue).

- stage two was to research the perception of information when three parameters are being changed: the LCD screen resolution (640x480, 800x600, 1024x768 pixels), sign angle sizes and its brightness contrast where the value of brightness contrast was some fixed values in range [1-10] with color changing of pictures being displayed (white, red, yellow, green and blue).

Angle sizes of symbols being displayed were controlled by the software with fixed distance between watcher eye and the MFDU screen. This distance is equal to the distance between the pilot eye and the avionics item during its exploitation. Some experiment results are given in the figure 3 (contrast ratio 1.0).



a) b) c)

Figure 3. Probability (P) in % to perceive the symbols of white color with different screen resolutions: a) symbol A, b) symbol B, c) symbol C.

Studying the probability connection of symbols from its brightness contrast with the screen resolution of 640x480 — 1024x768 pixels we can say that any increase in symbol display contrast on the MFDU screen with higher resolution increases the probability to be perceived.

5. Conclusion

The conclusions of done research are the following points of practical significance for avionics designers: application of minimal symbol sizes to form maximum saturated indicative frame with the screen minimal resolution is not effective even if the display contrast was increased significantly; the most effective symbol color to be perceived of minimal size (10, 12 angle minutes) on the black background is white then we can see green, red and blue colors.

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