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Effective Use of Colors in HMI Design

Shreya Deodhar, Prachi Agrawal, Aditi Helekar
(Electronics & Telecommunication engineering in University of Pune , India)
(Electronics & Telecommunication engineering in University of Pune, India)
(Electronics & Telecommunication engineering in University of Pune, India)

ABSTRACT
Nowadays majority portion of the operations in modern manufacturing industries are performed by the implementation of automation technology. All automation technologies employ a graphical Human Machine Interface (HMIs) to interact with the machine. Color is a major component of the HMI. The main characteristic of the HMI is that it should be intuitive and user friendly. With the use of appropriate colors, the HMI can be designed in such a way that the user focuses only on the specific part of the interface at that specific time period. Choosing the right color for the background, control buttons, alarms, text and other objects is very critical to design a good HMI. This paper will briefly examine theoretical and practical aspects of these components and the established techniques for the effective use of color in graphical HMI. A survey was conducted in order to support the findings of the study.

Keywords **-** Colors, Display, Graphics, HMI-Human Machine Interface, Objects

I. INTRODUCTION

In order to achieve high productivity from the automated machineries used in the industries, the issues of end-product equipment safety, ease of operation and reducing human error become extremely important. Human machine interfaces (HMIs) provide means to the operators to see, touch and control high stress industrial processes through touch screen displays. The two major factors to be considered while designing the HMI are, the screen must be able to hold operator's attention with maximum display clarity and the design must allow a person with no training or little experience to be able to successfully operate a machine.

According to a previous study, every color creates a different emotion in a human being [2]. According to Murch, a well-known human factors researcher, "Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if it is used properly"[1]. The communicative properties of a color can help in designing an effective HMI. For example, Blue triggers the sense of calm and red color of danger [3]. For a good design, the HMI would rather be simple than having big flashing animated lights, vessels with bright colors, or moving conveyors. Putting big bright measurement units is a bad idea. Also number of colors included in the design should be limited.

II. THE PROPOSED TECHNIQUES

2.1 Background Color

It has been observed during many previous studies that warm colors such as red, yellow, and orange are better in drawing one's attention to particular areas of the display [3]. Use of such warm colors should not be used for large areas of the screen as they degrade the performance by continuously drawing attention to them. Use of blue and green colors may fail to draw attention. Thus it can be argued that cool colors make better backgrounds and theme colors because of their tendency towards balanced representation of feelings [3].

An HMI graphic should always have a dull background (preferably grey). There should be no animation and crossing lines should be avoided, so that the operator does not get distracted from important data. Primary colors (red, green, blue) should never be used as background. Black and white colors are generally not used in background due to their characteristic of causing a glare. According to a study [3] brown and grey colors are dull and do not draw attention. It is always recommended to use pastel shades such as light grey, light brown in the background. These colors are easier to look and provide good contrast for the dark/ brighter colors (i.e. red, yellow etc) used for other components in the display page. While incorporating multiple pages, multiple shadows are used for each page so that the operator can visually identify different pages even from a distance.

2.2 Display Colors for Objects

According to SCADA/HMI Design Standard [4], there are few colors those specifically should be used for representing certain operations. They are:
Red →Stop, Emergency or Prohibition
Green →Start or Safe Condition
Yellow → Warning

Blue →Mandatory Operation

These colors should be clearly visible to the operators. Also if these color conventions are being followed in a design, then they should be strictly followed and similar colors should not be used to indicate any other actions. This will help reduce the misinterpretation or confusion for the operator. Dark colors should not be in screen in large blocks because they can create complementary color image retention on the retina [5].

Let us consider a standard object (Meter) from the microchip's graphic library. As shown in the figure 1, it shows six colors. This object all by itself will not indicate any information. Colors have to be chosen according to the application. Figure 2 indicates a speedometer it is a simple meter consisting of three colors. It can be observed that though minimum amount of text is present on the screen, it is not at all hard to interpret. The figure 3 uses the same object however now with different colors. The purpose of this screen can also be easily interpreted. It is the meter indicating the solder mixture composition. The green indicates the desirable area and the actions to be taken in case of the red areas are clearly mentioned. Figure 2 and Figure 3 are superior representations. When asked in the survey, 99% of the users were able to correctly identify the representation.

Attention to detail is important. It is typical to use bar charts to show relative positions and values. While this may be better than simply showing numbers, it is inferior to the use of moving elements since as the bar's value gets low, the bar disappears as seen in Figure 4.

The human eye is more likely to see the presence of an object rather than the absence. As shown in Figure 5 the representation can be improved. Also as the quantities are one below the other they can be easily compared.

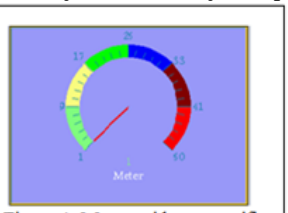

Figure 1: Meter with no specific information

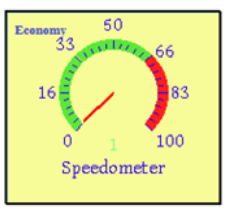

Figure 2: Speedometer

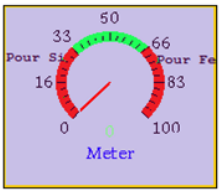

Figure 3: Range for solder mixture

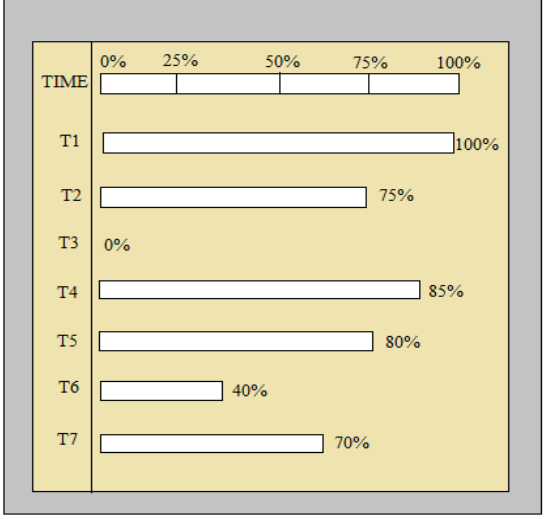

Figure 4: Traditional way of representing a bar graph

2.3 Text

Text in the HMI screen is the easiest way to convey information to the operator. However a screen should contain minimum text. Proper font and color should be used in the display so that an operator should not face any difficulty in reading and understanding the information. It is always wise to choose fonts which are commonly available in most of the computers, such as Arial, Times New Roman etc.

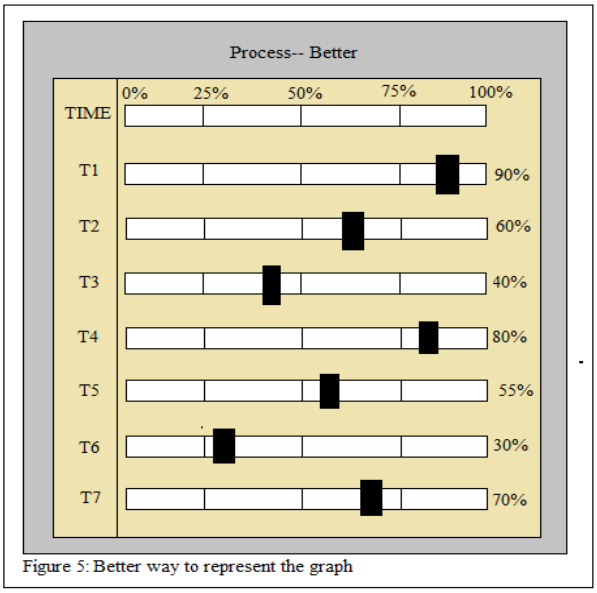

Figure 5: Better way to represent the graph

The size of the text should be as such that the operator can read the key information from several feet distance without and all the text should be black. Alarm text should be red and warnings in yellow. Thin blue lines (like blue text) tend to blur, and small blue objects tend to disappear when we try

to focus on them. Colors such as blue, green, yellow should be avoided for text. These findings were also proved by the supporting survey.

2.4 Alarm

Alarm and event information are the most important parts in the HMI screen design because it enables the operator to identify system operations and avoid critical situation those may arise during a process.

An event occurs whenever an operator reacts to alarms or makes any changes to the system. Alarms consider changes in a process or in its control system (i.e. operator action, configuration changes etc) those need to be recorded. HMI touch-screen, alarms and process feedbacks should consist of the following types:

Informative or Predictive: No action required. These can use green color, as these are not urgent and are needed only for user feedback. e.g. "Process Complete" (informative).

Warning: Process may or in 99% cases may not produce damage even if no corrective action is taken immediately. These generally use yellow. e.g."Improper Lubrication".

Blocking: The controller takes an action against any risky condition to protect the process and further operation is prevented until the reason is cleared. e.g. "Motor Jammed"

When a fault occurs, the separate alarm indicator appears next to it . The indicator keeps on flashing while the alarm is unacknowledged (one of the very few proper uses of animation) and ceases flashing after acknowledgement, but remains as long as the alarm condition is in effect. People do not detect color change well in peripheral vision, but movement, such as flashing, is readily detected. Alarms thus readily stand out on a graphic and are detectable at a glance.

Bright colors are primarily used to bring or draw attention to abnormal situations, not normal ones. Screens depicting the operation running normally should not be covered in brightly saturated colors, such as red or green pumps, equipment, valves, etc. When alarm colors are chosen, such as bright red and yellow, they are used solely for the depiction of an alarm-related condition and functionality and for no other purpose. Figure 6 shows a fault depiction. In further details the fault should be specified as shown in Figure 7. If color is used inconsistently, then it ceases to have meaning. [5].

MODULE	STATUS	MODE
HEATER 1	ON	AUTO
CHURNING MOTOR	OFF	MANUAL
HEATER 2	ON	AUTO
BRUSH	DISABLED	AUTO

ERROR

Figure 6: Error flashing

Proper screen layout is very important for a good HMI display. Generally, a human operator scans an HMI screen as any other regular screens, starting from top left corner to right and then down the screen. The human scanning pattern is as shown in Figure 8. So, the important objects of a system should be in an area within the page where the operator's attention goes easily. The alarms should be on the top of the page. Any graphical image object should be on the center left with key data on the center right of the page.

MODULE	STATUS
HEATER POWER ON	OK
MOTOR ON	OK
FAN ON	FAULT (OFF)
BRUSH	ERROR

Figure 7: Fault indication

It is recommended that start, stop or controls are kept in the lower left side and the navigation on the lower right side of the page.

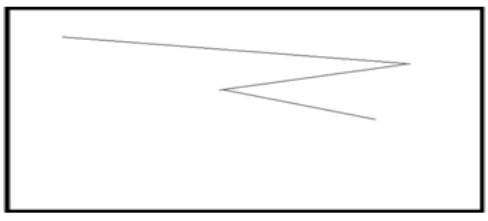

Figure 8: Screen scan path of a human eye

2.5 Process diagram:

Many a times while designing the HMI, it is important to include a representation of the complete process flow in the HMI screen. This makes the operators to visualize the plant and identify the locations of the measurements. A good HMI should always have consistent process flow direction and the

use of color must be limited. An HMI graphics should always include trends so that the operator can easily follow the behavior of a plant and monitor possible excursions.

In doing this, vessel levels should not be shown as large blobs of saturated color. A simple strip depiction showing the proximity to alarm limits is better [5]. The Figure 9 shows an appropriate depiction of a process diagram.

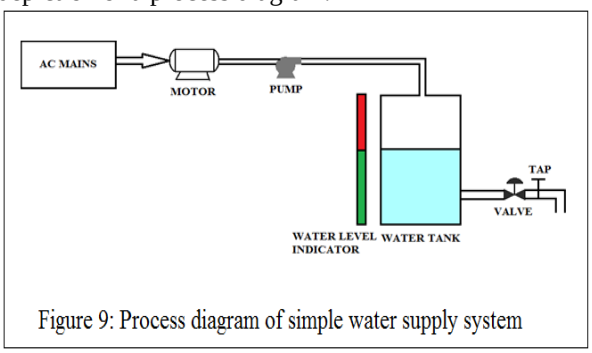

Figure 9: Process diagram of simple water supply system

III. CONCLUSION

As HMI systems are turning to be the principal point of contact between the user and the machine, a good HMI display makes this interaction flawless and smooth. This study concludes that appropriate use of color proves to improve the design of an HMI tenfold. In order to focus the user's attention, colors chosen for the background should be dull and those for objects and text should be attractive. Also it was concluded from the supporting survey that, generally users are not able to differentiate between the shades of green and blue. Finally we can conclude that in an HMI the representation should be crisp and to the point. No unnecessary decoration should be tolerated .Use of color should be made only to add information thus making a better design.

IV. ACKNOWLEDGMENT

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