WHITEPAPER

Optimizing Information Display in the Control Room

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Visual space and visual acuity are two important concepts to consider when designing and specifying effective information display in control rooms.

In Part 1 of my white paper: *The Future of Control Room Visualization* I explore human visual space and visual acuity with a more detailed explanation of visual acuity in the addendum.

In outline: human visual space for a seated operator in a control room is typically around 90 degrees horizontally and 60 degrees vertically, up to 120 degrees horizontally and 90 degrees vertically if the operator's console seating allows for a comfortable amount of swiveling side-to-side and rocking back.

With respect to visual acuity, the human eye (with 20/20 vision or corrective lenses) has an angular resolution, at its very center only, *foveal* vision, of approximately 60 pixels per degree of the visual arc.

We can thus calculate the human visual space for someone sitting at a console as being between 20 million and 40 million pixels.

That is the total visual space of an operator including their desktop displays and their desk surface itself.

In Part 2, I explore new generation UHD (3,840 x 2,160) desktop displays, which are already broadly available in the $5-600 range for a 28" screen. Two such screens on an operator desktop will deliver over 16 million pixels of information for under $1,600 per operator including a suitable graphics card.

But the big investment in a control room is typically a video wall, which will display the common operating picture, be it a SCADA/One Line or cameras, maps and other data relevant to all those in the control room.

Rather than discuss the different video wall display technologies available I would like to focus on one critical component: pixel size (or pitch or density) which is typically the major cost driver regardless of the display technology chosen (with the exception of SNB LCD where individual panel size and resolution are pretty standard today across nearly all suppliers: 55" diagonal, 1920 x 1080 pixels).

If there wasn't a cost involved, there would be no real downside to excess resolution, but since there is, the additional display cost to deliver resolution that exceeds the visual acuity of the nearest viewers is simply wasted.

The goal is to as closely as possible match the display pixel density to the viewing distance such that the operator is viewing the maximum information density that he/she can comfortably see. Since visual acuity is angular, the optimal pixel size, matching the viewer's visual acuity, will depend solely on the viewing distance.

For any given pixel size there is a corresponding minimum optimal viewing distance (MOVD): the distance beyond which the full resolution of the display is simply not visible or useful.

To illustrate this, consider an LED display in a sports stadium or on the side of a building in Times Square. From across the stadium or the road, the latest generation displays can look as good as your home HDTV, but up close they dissolve into their component pixels and are completely un-viewable.

Of course, those in a control room may be viewing the video wall from different distances, but you want to consider those closest when calculating the optimal display pixel size.

Or consider a movie theater. Those first to arrive will typically choose seats in the middle rows for which the screen size and resolution are optimized, by design. For those sitting in the front row, watching the movie will be much less satisfying: the screen will exceed their comfortable visual space and the film will tend to look pixelated (or blurry if the projection is still film based rather than digital).

For control room operators it will be an uncomfortable experience sitting in front of a large display that does not at least match their visual acuity and it will likely compromise their ability to comfortably see the information displayed.

So how does one calculate the optimal pixel size (or pitch or density) to match the visual acuity of the closest viewer: typically those in the front row of consoles?

It is a simple trigonometric calculation since we know the angle: 1/60th of a degree corresponding to the effective resolution of the eye, and since we also know the minimum viewing distance (the adjacent), we can solve for the height (the opposite) which is the corresponding pixel size, typically stated in millimeters.

To avoid the need to convert any units of measurement, the formulas below all adjust for the fact that pixel size/pitch is typically measured in millimeters and diagonal screen sizes in inches, globally, and in the USA viewing distance is measured in feet.

Here is a simple factor to use:

Take the minimum viewing distance in feet and divide by 11 (11.27 to be exact) and that will give you the optimal pixel size or pitch. It is that easy.

Minimum Viewing Distance (in feet) divided by 11 = Optimal Pixel Size (in millimeters)

Or if you are considering a particular display, take the pixel size or pitch in millimeters and multiply by 11 (11.27 to be exact) and that will give you the optimal minimum viewing distance in feet.

Pixel size (in millimeters) multiplied by 11 = Optimal Minimum Viewing Distance (in feet)

The factor to convert instead to meters is 3.5 (3.44 to be exact), so:

Minimum Viewing Distance (in meters) divided by 3.5 = Optimal Pixel Size (in millimeters)

Pixel Size (in millimeters) multiplied by 3.5 = Optimal Minimum Viewing Distance (in meters)

If you don't have the pixel size information available, but only the individual display diagonal (in inches) and the resolution, here is how to calculate it.

4:3 Aspect Ratio

XGA (1024 x 768)
SXGA+ (1400 x 1050)

Screen Size (in inches) multiplied by 20 then divided by number of Horizontal Pixels = Pixel Size (in millimeters).

16:9 Aspect Ratio

WXGA (1,280 x 720)
HD (1920 x 1080)
UHD: '4K' (3,840 x 2,160)

Screen Size (in inches) multiplied by 22 then divided by number of Horizontal Pixels = Pixel Size (in millimeters).

16:10 Aspect Ratio

WUXGA (1,920 x 1,200)
WQXGA (2,560 x 1,600)

Screen Size (in inches) multiplied by 21.5 then divided by number of Horizontal Pixels = Pixel Size (in millimeters).

So for an SXGA+ 67" cube the calculation is: 67 (diagonal inches) x ~20 = 1,340 divided by 1,400 (number of horizontal pixels) = ~ 1mm pixel size and ~1mm x ~11 = ~11ft optimum minimum viewing distance.

Please note: two of these factors are rounded. 4:3 exact factor is: 20.32, 16:9 is: 22.1.

For your reference here are the approximate pixel size and optimal minimum viewing distance ranges for different types of displays that might commonly be found in a control room:

- Laptop screens: 0.1-0.2mm. 13"- 26"
- Desktop screens: 0.15-0.25mm. 22"- 34"
- SNB LCD (55" full HD): 0.6mm, 6.75ft
- Projection Cube: 0.7mm-1.66mm, 8ft -18ft.

Again, these are optimal minimum viewing distances. The viewer may be further away, but they will not want to be closer and if there is a lower resolution display that still meets the OMVD requirements of the closest viewer, it's the smarter choice.

Please note: certain projection cube manufacturers, in order to make their cabinets slimmer, use digital signal processing (DSP) based pixel morphing in order to compensate for the resulting optical distortion. Using much higher pixel density helps mask the DSP related artifact. This paper assumes direct mapping between the graphics card and the individual pixels (e.g. LCD pixels or DLP mirrors).

Paul Noble, CEO of Activu, is an entrepreneur with a unique blend of tech and business experience. He founded Activu Corporation (formerly Imtech) over thirty years ago in New York, making it the first company to develop and sell video wall technology in the United States. Born in London, Paul attended the London Film School and had an early career in film and television before moving to the United States. He later went on to receive an MBA from Columbia Business School. He can be reached at paul.noble@activu.com.