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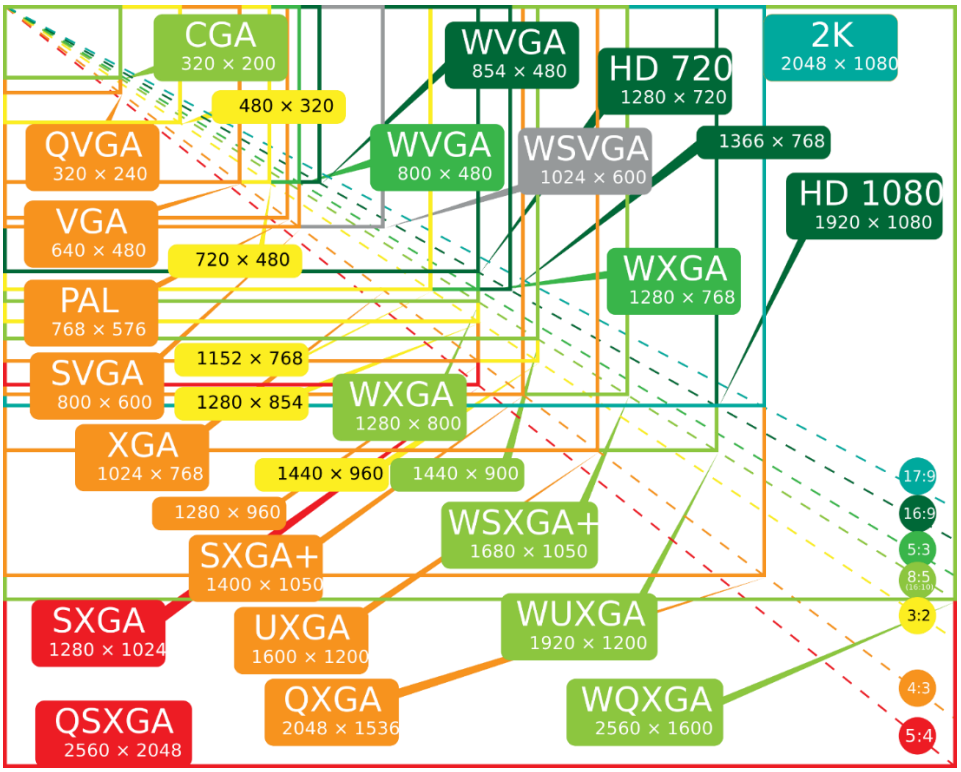
DISPLAY TECHNOLOGY

PROJECT: THE DISPLAY RESOLUTIONS



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Content

1 Introduction

This is a project to the Display Technology course. It contains the basic information about the display resolutions which have been used in the past and also which are being used nowadays.

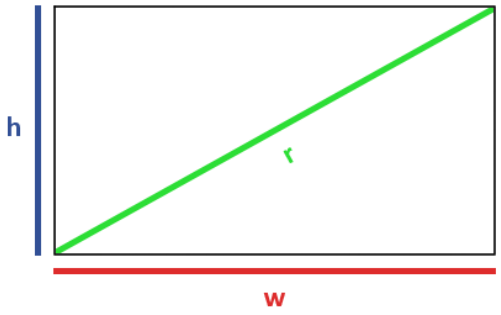
Due to the large number of the resolutions which have been developed and used during the display technology period, I picked those resolutions that I think they were/are most common used or interesting.

2 What the term *resolution* means

In display technologies the term *resolution* should mean the number of horizontal and vertical pixels on the display screen. It is usually quoted as **width x height**, such as 1600x900, which means that the display screen has 1600 horizontal pixels and 900 vertical pixels.

2.1 Screen resolution vs. aspect ratio

It is important to say that the term *screen resolution* is not equivalent to the term *aspect ratio*. For example the 1366x768 (HD) resolution has 16:9 aspect ratio, but the same ratio have another screen resolutions, such as 1600x900 (HD+) 1920x1080 (Full HD).



w = 1600 px

h = 900 px

r = 1600 : 900 = 16 : 9

We can count (or approximate) the aspect ratio from the resolution but we cannot count the resolution from aspect ratio. The table below shows how the ratio between screen width and height in pixels depends on some common known screen aspect ratio:

RESOLUTION	WIDTH/HEIGHT	ASPECT RATIO
1600x1200	1.33 : 1	4 : 3
1024x768		
800x600		
1920x1080	1.78 : 1	16 : 9
1600x900		
1366x768		
4096x2160	1.89 : 1	17 : 9
2048x1080		

2.2 Native resolution

The term *display resolution* is also related to fixed-pixel-array displays, such as plasma display panels (PDPs), liquid-crystal displays (LCDs) and others. While the CRT screens can usually display images at different resolutions, the LCD or plasma displays have fixed resolution. This fixed resolution is known under the term *native resolution*. And what does it mean in practice? The resolution is physical number of columns and rows of pixels that create the display and the best display quality is reached only if the signal input is the same as the native resolution.

3 TV screen resolutions

As it was said in the beginning, the term display resolution should mean pixel dimensions, the number of pixels in each dimension (1600x900), which does not tell anything about the pixel density, the number of pixels per unit distance or area.

But there is a difference related to the resolutions of TVs. It is usual that the resolution of TV is quoted as (for example) *720p* or *1080i*. The number means a number of lines which make the screen. The letter means the technique, which is used to paint the screen. The letter '**p**' is used for the technique called **progressive scanning** and 'i' is for **interlacing**. The difference between this two techniques is described below.

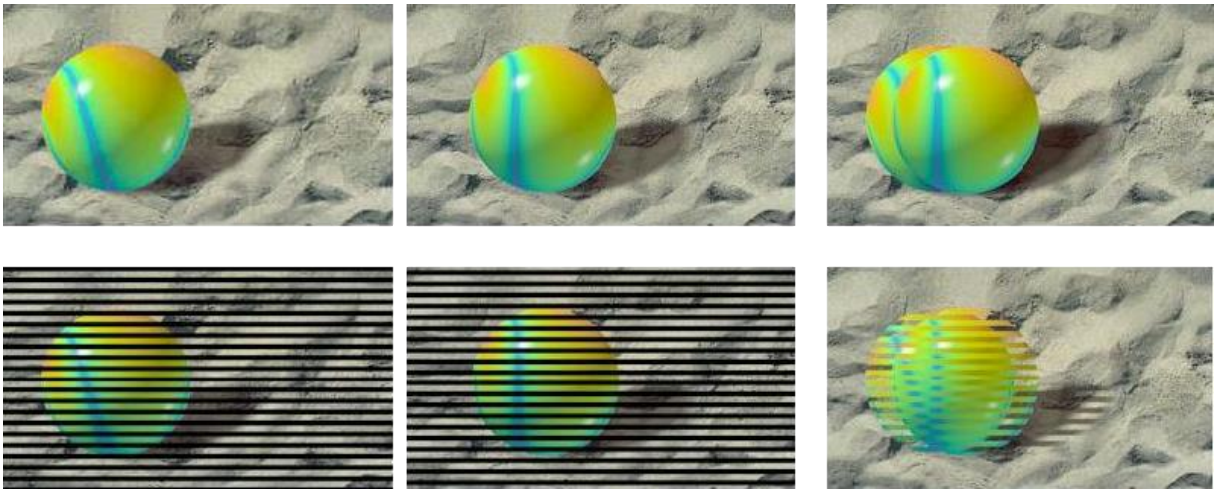
3.1 Progressive scan vs. interlacing

3.1.1 Progressive scan

The screen is painted 60 times per second with every line painted per frame. This technique is better than interlaced because it processes the images twice as fast and it reduces flicker.

3.1.2 Interlacing

The screen is painted 60 times per second but only half of the lines are painted per frame. Usually it starts with painting the odd-numbered lines from left to right and after that it paints the even-numbered lines.



the first row: progressive scan

the second row: interlacing

As expected, the more lines, the better should be the quality of the screen. But we also have to take into consideration the painting technique. For example: The 720p resolution is more recommended than the 1080i, because the difference between 720 and 1080 lines is small but the progressive scanning makes smoother image.

3.2 Common used TV resolutions

There is a lot of TV resolutions – some of them were used in the past (SDTV, EDTV), some of them are used now (HDTV) and some of them are the things of future (UHDTV).

Nowadays, TVs have mostly 720p, 1080i, 1080p or newly 2160p (4K).

3.2.1 Standard-definition TV (SDTV)

480i

- NTSC-compatible digital standard (most used in America)
- two interlaced fields of 243 lines each

576i

- PAL-compatible digital standard (most used in Europe)
- two interlaced fields of 288 lines each

3.2.2 Enhanced-definition television (EDTV)

480p

- 720 × 480 progressive scan

576p

- 720 × 576 progressive scan

3.2.3 High-definition television (HDTV)

720p

- 1280 × 720 progressive scan

1080i

- 1920 × 1080
- two interlaced fields of 540 lines

1080p

- 1920 × 1080 progressive scan

3.2.4 Ultra-high-definition television (UHDTV)

2160p

- 3840 × 2160 progressive scan
- quoted also as *4K UHD*

4320p

- 7680 × 4320 progressive scan
- quoted also as *8K UHD*

8640p

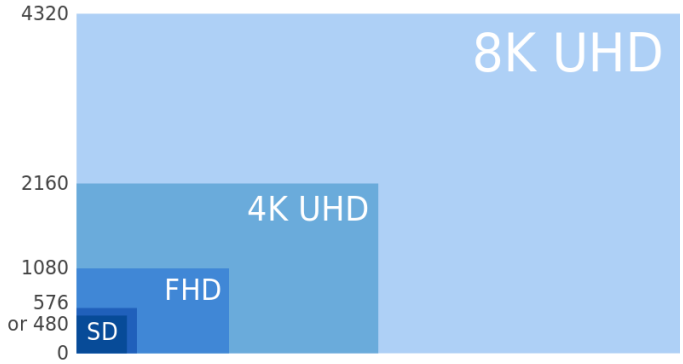
- 15360 × 8640 progressive scan

3.3 4K and UHD TV

On October 17th, 2012 the Consumer Electronics Association announced, that "*Ultra High Definition*" would be used for displays that have an aspect ratio of 16:9 and at least one digital input capable of carrying and presenting native video at a minimum resolution of 3840x2160 pixels.

Ultra High Definition television – also known as 2160p, UHD-1, Super Hi-Vision, Ultra HD television, UltraHD, UHDTV or UHD – includes 4K UHD (2160p) and 8K UHD (4320p).

On the picture below you can see comparison of sizes of these resolutions:



As you can see, 4K UHD resolution is 4 times larger than the Full HD resolution and the 8K UHD resolution is 4 times larger than the 4K.

There is an increasing trend in producing bigger and bigger TV resolutions. In 2015 has begun a boom with 4K televisions – and it is still continuing now, in 2016 – because they are now available in market for more affordable prices than ever before.

3.3.1 Difference between Ultra HD and 4K

Technically, "Ultra High Definition" is actually a derivation of the 4K digital cinema standard. However while local multiplex shows images in native 4096x2160 4K resolution, the new Ultra HD consumer format has a slightly lower resolution of 3840x2160.

This is one reason why some brands prefer not to use the 4K label at all, sticking with Ultra HD or UHD instead.

3.3.2 Cost of 4K TVs

The first 4K TVs were large – they had 84 inches. And large was also their price. The first ones cost about $30,000 – $50,000! However, prices have fallen dramatically as screen sizes have shrunk. Now it is possible to find 4K TVs for less than $1000.

3.3.3 Size of 4K TVs

The 4K TVs are likely to be 55-inches and more. Why not smaller? Because such pixel density that has 4K resolution would be useless in smaller display.

4 Computer screen resolutions

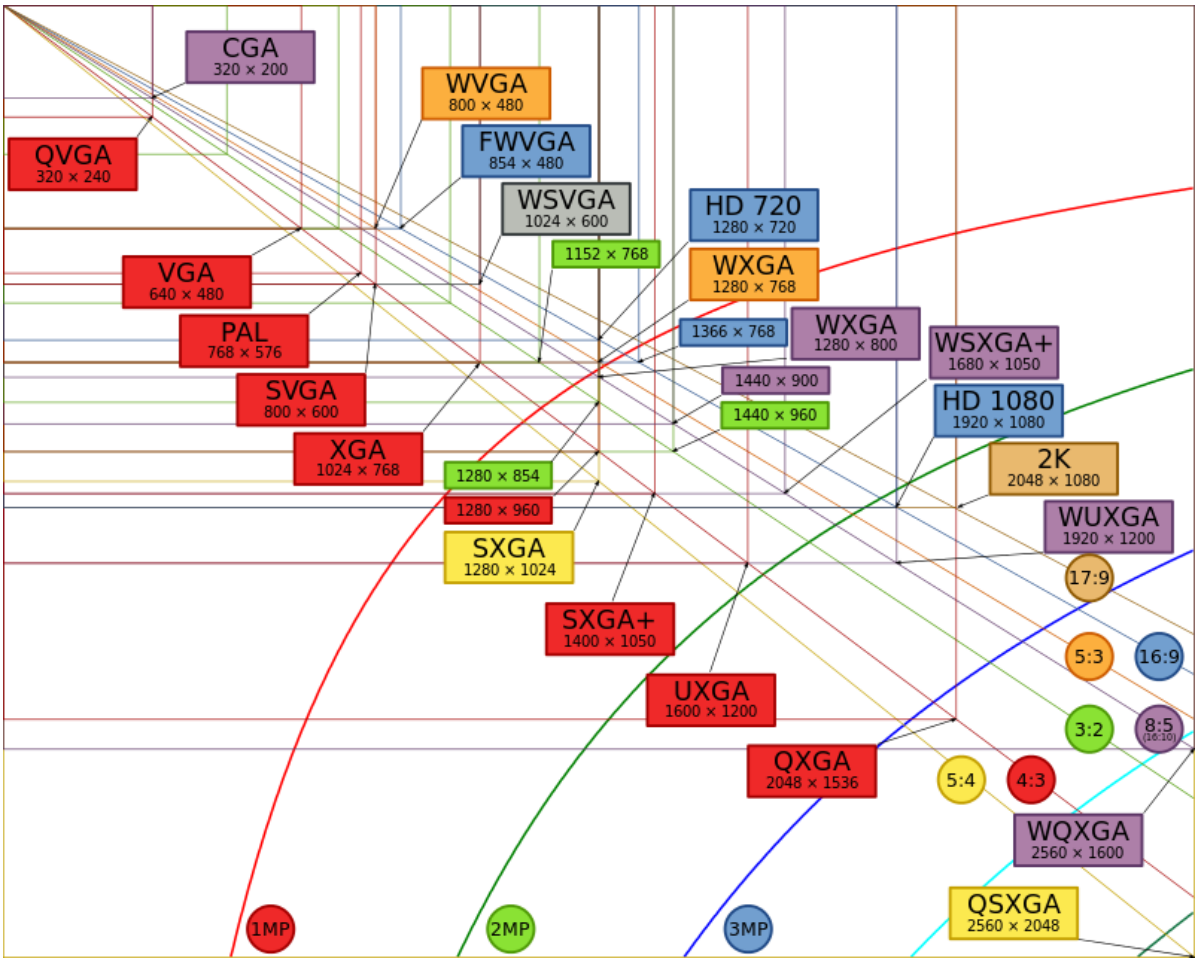
4.1 History

A lot of the computer screen resolutions have been used during the history of the computers. A number of common used resolutions descended from the original IBM PC. There resolutions are considered as standards. (Note: the IBM PC was the one of the first personal computers and its success made other companies to develop components that were compatible with it.)

The first computers had the NTSC output because they were intended to work with TV set as a computer screen. As we know, after some time we started to use screens that were developed for being just a computer screen (not TV). And as the technology was getting better, the computer screen resolutions were getting bigger and bigger.

4.2 Common used computer resolutions

The most common used computer resolutions are shown in the image below:



There are some resolutions, that were used in the past (QVGA, VGA, SVGA, XGA…), some that are used nowadays (HD, WXGA, HD+, UXGA, Full HD, QXGA, WQXGA, QWXGA+, 4K UHD,…) and of course, new resolutions are being developed now (8K UHD).

The computer screen resolution is also called “graphics display resolution”, which is the width and height dimensions of an electronic visual display device, in pixels. Certain combinations of width and height are standardized and typically given a name that is descriptive of its dimensions. A higher display resolution in a display of the same size means that displayed content appears sharper.

4.2.1 Aspect ratio

The aspect ratio of display industry products has changed from 4:3 to 16:10 and then to 16:9.

The 4:3 aspect ratio was generally used by older products, especially the cathode ray tube displays. The 16:10 aspect ratio was mostly used in the 1995–2010 period. And the 16:9 aspect ratio is used in nowadays computer monitor and laptop displays.

4.2.2 Computer resolutions in the past

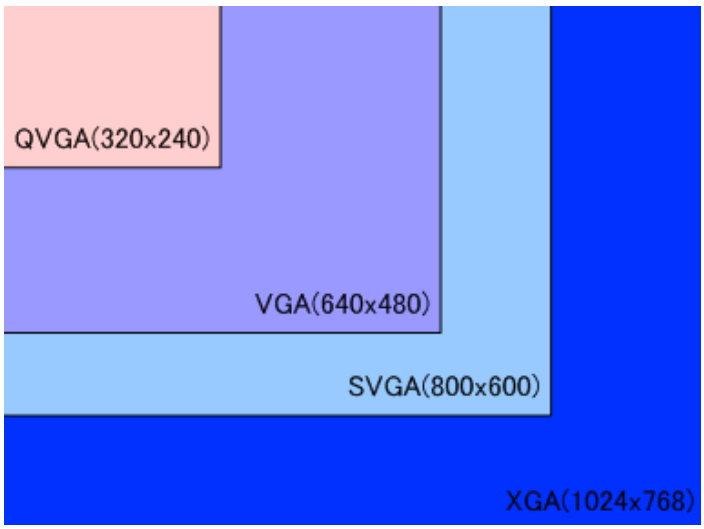
The computer resolutions in the past are mostly derived from the IBM VGA display technology, which became an industry standard in the 1980s. The VGA is still the universal fallback troubleshooting mode in the case of trouble with graphic device drivers in operating systems. In the field of videos the resolution of 640x480 is called Standard Definition (in comparison to High Definition).

QVGA

- **Q**uarter **V**ideo **G**raphics **A**rray
- 320 x 240
- aspect ratio: 4:3
- used in portable devices such as PDAs
- used both in portrait and landscape modes

VGA

- **V**ideo **G**raphics **A**rray
- 640 x 480
- aspect ratio: 4:3
- developed in 1987
- IBM-compatible
- became a standard in computer displays



SVGA

- **S**uper **V**ideo **G**raphics **A**rray
- 800 x 600
- aspect ratio: 4:3
- developed in 1989
- IBM-compatible

XGA

- e**X**tended **G**raphics **A**rray
- 1024 x 768
- aspect ratio: 4:3
- developed in 1990

4.2.3 Computer resolutions used nowadays

HD

- **H**igh **D**efinition
- 1366 x 768
- aspect ratio: 16:9
- most used in recent notebooks and desktop monitors alongside with Full HD resolution

WXGA

- **W**idescreen e**X**tended **G**raphics **A**rray
- 1280 x 800
- aspect ratio:16:10
- most used in notebooks until ca. 2010 (before the HD resolution)

HD+

- **H**igh **D**efinition **P**lus
- 1600 x 900
- aspect ratio: 16:9
- used in recent notebooks and desktop monitors

UXGA

- **U**ltra e**X**tended **G**raphics **A**rray
- 1600 x 1200
- aspect ratio: 4:3
- native resolution for many 20" LCD monitors

Full HD

- **Full H**igh **D**efinition
- 1920 x 1080
- aspect ratio: 16:9
- most used in recent notebooks and desktop monitors alongside with HD

QXGA

- **Q**uad e**X**tended **G**raphics **A**rray
- 2048 x 1536
- aspect ratio: 4:3
- the highest resolution that can be displayed on analog computer monitors

WQXGA

- **W**idescreen **Q**uad e**X**tended **G**raphics **A**rray
- 2560 x 1600
- aspect ratio: 16:10
- native resolution for many 30" LCD monitors; used on the MacBook Pro Retina (13,3")

QWXGA+

- **Q**uad **W**ide e**X**tended **G**raphics **A**rray **plus**
- 2880 x 1800
- aspect ratio: 16:10
- used on the MacBook Pro Retina (15,4")

4K UHD (QFHD)

- **4K U**ltra **H**igh **D**efinition/**Q**uad **F**ull **H**igh **D**efinition
- 3840 x 2160
- aspect ratio: 16:9
- four times the resolution of 1080p
- sometimes quoted as *UHD* or just *4K*

4.2.4 Computer resolutions in the future

8K UHD

- **8K U**ltra **H**igh **D**efinition
- 7680 x 4320
- aspect ratio: 16:9

5 Cell phones & tablets resolutions

5.1 List of common used cell phones and tablets resolutions

	Width	Height		Width	Height		Width	Height
Older cell phones	84	48	Recent cell phones	540	960	Recent tablets	800	480
	240	320		640	960		768	1280
	240	400		640	1136		768	1024
	320	480		720	1280		1024	600
	480	600		750	1334		1024	768
	400	800		800	1280		1280	800
	480	800		1080	1920		1280	768
	480	854		1440	2560		2048	1536

As you can see, there is also a trend to make bigger and bigger resolutions. But we need to take into consideration, if it is still worth. The modern cell phones have displays about 4 to 6 inches, tablets have about 7 to 12 inches. It is a thing for thinking, if it is still worth to have a 1440x2560 resolution on 4-inches display instead of 1080x1920, because the pixel density is too high on such a small display and we can't see any difference with human eye anymore. But, of course, the bigger numbers look good in marketing and people want to have "the biggest" thing, because they think that biggest equals to the best – which is not always true.

Sources

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https://en.wikipedia.org/wiki/Interlaced_video

https://en.wikipedia.org/wiki/List_of_common_resolutions

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https://en.wikipedia.org/wiki/1080p

https://en.wikipedia.org/wiki/720p

https://en.wikipedia.org/wiki/Graphics_display_resolution