



Field of View Explained

for the iRacing community

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Preface

With iRacing striving to offer the most tremendous and immersive simulated experience of car racing on an affordable level, the sim racing community tries to maximize iRacing's potential by setting up dedicated driving rigs at home, building virtual cockpits, comparing every minute detail of the simulation to real-life racing and discussing its realism. However, my experience in the recent discussion about *field of view* lead me to believe that quite a few people don't understand the concept behind the term. It's astonishing how much more immersion and realism we can get out of iRacing by setting up the field of view correctly. So I researched the matter further and wrote this paper as a guide for everyone who plays racing sims or even "3D" computer games in general, where field of view is often misunderstood and not properly applied.

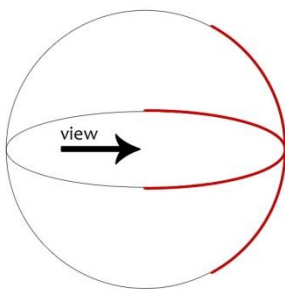
Understanding field of view in real life is key to getting the most out of your simulation experience.

On the following pages we will take a look at how field of view works on flat panels such as TV and computer screens, and how it is represented in games. By the end of the guide you will know how to correctly set up your field of view for iRacing!

Part 1: Definition of field of view

1.1.: Field of view in real life

The field of view (or field of vision, abbreviated FOV) is the range of what our eyes can see, usually measured in degrees. For humans, the horizontal field of view is larger than the vertical because we have two eyes arranged next to each other horizontally. Some animals have their eyes in different positions and receive a much broader or narrower field of view. [Wikipedia states](#) that human field of view is 180° horizontally and about 100° vertically.



This means that we can see half a circle of a full 360° panorama of the world around us at any moment. If we look straight ahead with both eyes and focus on something, we can still see what happens 90° to the left and right, albeit with constraints such as blurred vision and less accurate coloring. The same applies to the 100° circle that we can perceive on the vertical line of sight.

It's important to understand that our field of view is *not flat, but circular*. Because the world “wraps around” us and our eyeballs are round, we can see stuff that is next to us and not directly in front of us. However, it should be clear that since TV and computer screens are flat, real-life field of view cannot be represented accurately on photos, in films and computer games. We would have to “wrap” the represented world around us which is not possible unless we use a circular display (like in an IMAX theater).

1.2.: Focus view and peripheral view

There is a kind of fluent crossover between the area that we can see clearly, which I will dub “*focus view*”, and the area around this focus where we can perceive, but not clearly identify objects, which can be called “*peripheral view*”. Even though the crossover between these two areas is circular, you could “frame” the focus view in a rectangle of approximately a 16:9 ratio, like a computer screen.



When screens were switched from the old 4:3 to the modern 16:9 ratio (with 16:10 being a derivative), it was done in an effort to more accurately portray the aspect ratio of our real-life field of view. This means if we just get a monitor that is big enough and put it close enough to our eyes, we can fill our whole vision with the picture – however, it would still not “wrap around” our eyes if it was flat. That’s why it is most common to use a widescreen monitor in your focus view, either filling the area completely or (more often) being farther away at a comfortable distance that allows you to see the whole screen without moving your eyes much.

Please note at this point that because 16:9 is the natural aspect ratio, this guide assumes you are using a 16:9 screen. The suggested field of view settings will look different on a screen with another aspect ratio, so keep that in mind if you use one!

1.3.: Focal length

Every photographic lens, including our eye, has a focal length which determines how far out a three-dimensional picture “stretches”. The shorter the focal length, the further stretched out the world will seem. If we “zoom in” by increasing the focal length, the world in our “picture frame” will become larger, but the third dimension will be “compressed” with objects far away becoming bigger than before in relation to close objects.

As a result, distance seems to be shorter – an object 20 meters away from another object that’s much closer might appear 10 meters away when looking through a lens with great focal length. We can therefore artificially increase or decrease the perception of depth, distance and size of objects on a picture by using different focal length.



A portrait taken with a focal length of 100 mm, 50 mm and 24 mm.

Part 2: Field of view on a flat screen

It will become clear in a moment how the previously mentioned terms interact differently on a flat screen compared to reality.

2.1.: The problem of presenting periphery



On a flat panel, such as a photograph, TV or computer screen, we have to resort to tricks if we want to present the full human field of view of a given area. Let’s assume we take a photo of a room: standing in a corner of the room, we could probably see all four walls, the floor and the ceiling as well as most of the furniture inside – in short, we could see the *periphery* around the *focus view*.

However, if we want to put this amount of visible information onto a photograph, we have to play with the *field of view* and *focal length* of the camera; otherwise we will have to sacrifice some of the area we can see with our eyes because again, the photograph is flat and does not “wrap” around us when we look at it. It cannot take up all the periphery from the room that we are seeing.

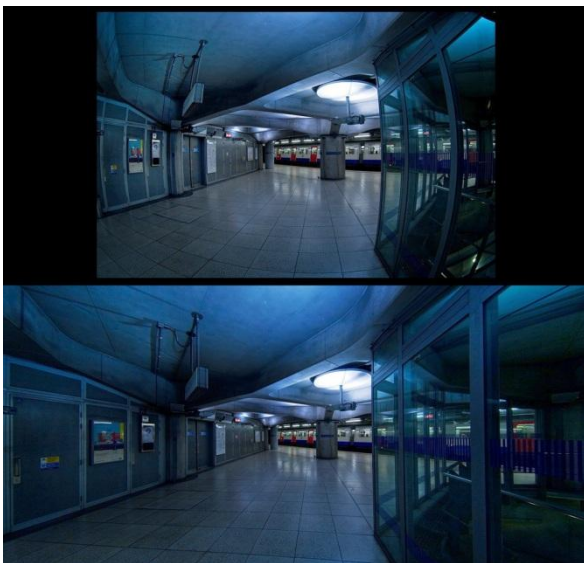
2.2.: Possible artifacts



By increasing the field of view of the camera, we can “zoom out” to a point that seems further “into the corner” of the room we are looking from. We will eventually get all the information onto the photograph, including the two walls closest to us that were most certainly not on the photograph before! However, this will usually result in a “fish-eye” type of vision where

the part of the room in the focus area becomes smaller, while the additional information we just added to the photograph will be “squeezed” onto it in a distorted way.

In a nutshell we could say that if you increase the field of view of a camera lens, you will get a distorted picture with less accurate object size, but more information because we can fill the same rectangle photograph with “more of the room”.



If we do the same thing for a video camera while moving forward, we will see that the sense of speed is distorted along with the sense of size and the peripheral vision. Because the focus view will become smaller on the picture, the objects in it will appear farther away from the camera than they are. In addition, the stretched out periphery on the sides of the picture will appear to move faster toward the camera than it really does. All this increases the perceived speed while the actual moving speed remains constant.

In the above picture, the original photograph was taken with a fish-eye type lens to include the periphery we don’t normally see on a photograph. However, the reworked image below it that has

the periphery stretched out to remove the fish-eye effect puts the focus area “farther away” from the viewer.

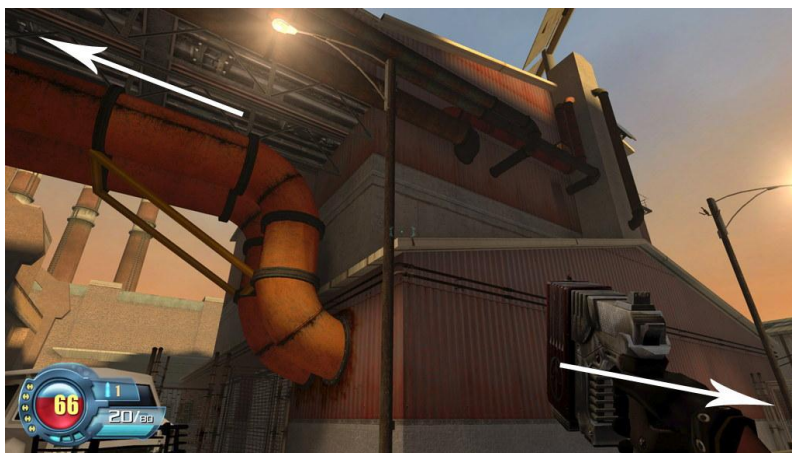


If we narrow the field of view, we will cut off more periphery until we arrive at the focus area and begin to cut off too. This will “zoom in” onto the objects in the very center of the focus view, making them appear larger and therefore closer to the camera than they are, and it might seem that these objects are coming toward us slower than before. Also, the resulting picture will seem “tunneled” and missing natural distortion toward the center point of the picture.

2.3.: Focal length in screen presentation

By changing the focal length, we can compensate for the peripheral distortion and the appearance of objects being farther away than they are. If we decrease focal length on a picture with a large field of view, we can bring the objects displayed in the focus area “closer” to the camera again. This will also result in less peripheral distortion and balance the picture while keeping the field of view as large as possible. This way, we can present a lot of visual information on a flat screen, but we sacrifice accuracy of distance and size – it’s a compromise to make it seem more natural to us when it really isn’t.

2.4.: Field of view in computer games



*Screenshot from SiN: Episodes.
One can clearly see the distortion towards the edges.*

Computer games that represent a three-dimensional world – such as first person shooters and role-playing games, flight simulations and racing/driving games – attempt to give the player the peripheral vision back that is missing when presenting an accurate (undistorted) flat picture of reality. Such a game might increase the field of view of the character’s “eyes” that we look through into the virtual world, presenting the periphery that “wraps around” the character to us on the edges of the flat screen we look at. Depending on how the game engine renders the world, there will be more or less distortion towards the edges of the picture. Objects in the focus view will be smaller than they really are, making it difficult to judge how large and how far away exactly an object might be.

If the engine also uses focal length changes to increase or decrease distortion, it might be able to produce a seemingly undistorted image that will also increase the size of objects in the focus area again. This is why some games might paint a “more accurate” picture of their world than others: in one game, objects that you can pick up or climb up to might look just the right size, while in another game such objects could appear smaller than you would expect from real life. One game might have a less distorted picture than another, but would also appear a little “short” in 3D depth compared to the other game. Judging distance to an object would undoubtedly be difficult for any of these games if you didn’t have a reference like a wall or the ground to “measure” the distance from your character to the object.



As a direct result, it is *virtually impossible* to represent a true-to-life field of view in a computer game when using a flat screen. What’s more, game designers will often come up with ways to make the game world more believable despite the inaccurate view of things, for example by making objects bigger than they would have to be. A classic example is a door between two commonly-sized rooms: in reality, such a door is about 2 meters tall, but in many games the height varies from relatively accurate to huge sizes, going as far as 3 meters. Because of the distorted field of view and the resulting size difference, such huge doors might not



appear “too tall” when viewed from a distance, but once you stand right in front of one and look up, you will notice the size difference between your character’s eye height and the doorframe.

In racing games or simulations, such oversized objects are rarely the case because cars, tracks and objects are measured against each other to provide accurate, real-life sizes. Due to the increased field of view, though, it is especially difficult to judge speed and distance until you have become used to the experience and adjusted your perception accordingly.

Part 3: Correctly representing real-life field of view

With the following setup, it's possible to remedy the problems associated with the "fake" field of view that we have become used to through years of playing computer games. However, not every game can be set up this way, and we will look at the reason first...

As mentioned before, some games use focal length changes to *artificially reduce distortion* of the large field of view. In racing, many simulations seem to do this in a "middle of the road" range that does not compromise realism too much. It provides the player with a greater field of view to make important periphery visible, such as side mirrors and overtaking cars. The view often seems "right" in these sims even though the field of view is clearly too large, simply because the distortion is not as apparent as it would be with the *human focal length*. As such, many sim racers have become accustomed to this field of view and the advantage of seeing periphery on the screen that they really *cannot see in a real car* unless they turn their head.



Screenshot from *SHIFT 2: Unleashed*. The game puts the complete cockpit into view, but does not distort as much as iRacing would.

iRacing is a simulation that does not artificially decrease distortion of a large field of view. The focal length seems to be set to human standard because one can clearly see distortion towards the edges of the screen, especially in the cockpit view, with a field of view of 80° or greater (note that 80° is not

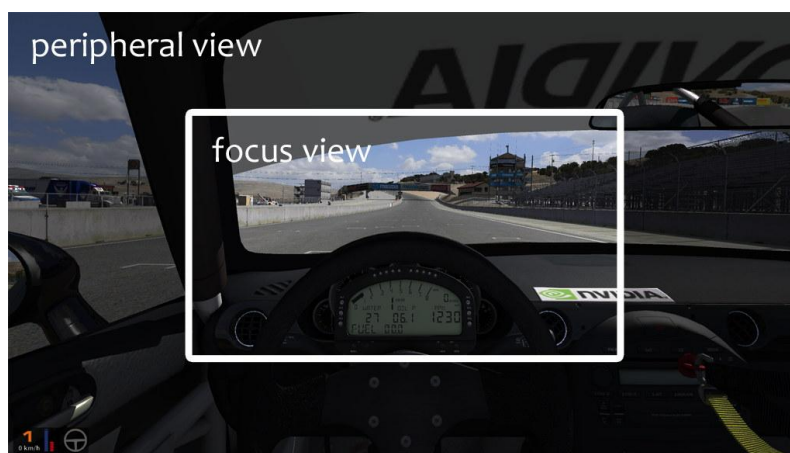
the appropriate real-world value). Some people might never have noticed it before, but compared to the cockpit view of another racing game that includes a changed focal length, it's obvious. It seems that iRacing's intent behind this is to make drivers use the *natural field of view*, sacrificing peripheral vision while keeping an accurate sense of distance, size and speed.



A field of view of 90° in iRacing puts the same cockpit perspective on the screen as SHIFT 2, but distorts noticeably towards the edges.

3.1.: Focus view on a flat screen

When sitting in a real car and looking straight ahead, you will usually see the full height of the windshield, the column to the left or right (depending on where you sit) and a part of the center console. This is what's in your *focus view*; everything else that you perceive such as mirrors, door windows and other cars next to you is *periphery*. If you want to look at the side mirror, you have to turn your head or at least move your eyes there. The correct approach for an accurate field of view in iRacing is therefore to limit what we see on the screen to the focus view we know from a real car.



If we set the field of view to 60°, we get approximately the same result, depending on the car and how far we'd like to sit to the front or back – although it is important at this point to note that moving your seat fore or aft is not the same as changing field of view, which changes your whole view while leaving the seat position unchanged!



We now have the focus view completely occupying our widescreen monitor, seeing what we need to see when we look forward. We will probably not see the mirrors or the bigger part of the steering wheel on the screen, but this view has the advantages that we previously looked at:

- distortion-free view with accurate sense of distance
- correct sense of speed
- accurate size of objects relative to your focus view

3.2.: Screen viewing distance and sense of size

“Relative to focus view” means that objects will appear as large as they need to be *if you interpret the view on the screen as your focus view*. This means that if you put the screen farther away from you than actually needed, everything will become smaller, your simulated focus view as well as the objects on screen. You can do three things at this point:

- bring the screen back toward you so it fills your real-life focus view
- compensate by getting used to the smaller size of your simulated focus view
- further decrease the field of view

If you go with the last option, you will be able to “zoom in” to the focus view and make on-screen objects even larger until they are life-sized and you feel like in the real car again. However, since the

screen is too far away from you, what you are doing is basically cutting off parts of your simulated focus view and discarding vital information that you would see in real life when looking straight ahead. I would therefore recommend leaving the field of view at 60° and bringing the screen closer to you until things feel large enough again, or compensating. Since most people have learned to compensate for a smaller screen *and* a larger field of view, getting used to a slightly smaller but still lifelike picture of your focus view should not be much of a problem.



A field of view of 45° cuts off important information from the focus area, but increases object size.

Monitor width including bezel:	565	<input checked="" type="checkbox"/>	mm
Visible width excluding bezel:	523	<input checked="" type="checkbox"/>	mm
Viewing distance:	452	<input checked="" type="checkbox"/>	mm
Angle between center and side screens:	0		°
Field of view when driving (45° to 160°):	60		°

To help you find out the correct field of view based on your screen's size and the distance of the screen from your eyes, iRacing has the *field of view calculator* built into the graphics options. It operates on the following formula:

$$2 * \arctan (0.5 * w / d)$$

with w being the screen width and d the viewing distance.

arctan means the inverse tangent function. (thanks to iRacer Andrew R. Macpherson)

It requires you to enter the width (not diagonal) of your screen's display without bezel in the appropriate field, either in millimeters or in inches. Next you enter either the distance from your eyes to the screen *or* your desired field of view (60° for an accurate focus view). Once you hit Return, the software will calculate either the required distance to sit away from the screen, or if you entered that, it will tell you which field of view you need. iRacing will fill in the missing information and once you click on "Done", you will see the effect immediately in cockpit view.

iRacing's goal here is to get lifelike size no matter how far you sit away from your screen by decreasing your field of view below 60° if necessary. If you want to keep 60°, it will tell you how close you must get to your screen to get the appropriate size. Once you do this, you will feel like you are in a real car, with every object being life-sized.



Comparison of many field of view settings on one picture. Perspective distortion is apparent at 125°. (thanks to iRacer Stephane Turpin)

Figuring out how far an object is away from your simulated car is largely based on the object's size. This means that if you have trouble compensating for the smaller focus view on your screen, you might feel that things are farther away in the simulation than they really are. This is why some people choose to use a much bigger screen (like a TV) at an appropriate distance so that they will get lifelike size, which could be considered a fourth option in addition to the already mentioned ones.

While the decreased sense of speed and the missing periphery such as mirrors (you can use iRacing's "virtual mirror" instead) can be disorienting at first, you will very likely get accustomed to the new field of view very quickly. Many racers have reported that they can take corners better because it's easier to judge how close the apex is. Also, the road itself seems much wider than before, something that is definitely true to life as I can confirm from personal experience: when I was on a racetrack for the first time, driving toward the first corner and looking at the pavement and curb strips proved to be overwhelming compared to what I was accustomed to from racing sims. Everything was much broader than I had imagined and it felt much more direct to go around corners. You will get the same effect with a properly set up field of view in iRacing!

3.3.: Adding peripheral view

Coming back to the start of this paper, you may remember that the problem with field of view on a flat screen was that the virtual world cannot “wrap around” us like reality does. What we have done in iRacing gives us back an accurate focus view, but the peripheral view is cut off. There are three solutions to this.



You can get a much bigger screen and sit closer to it than you normally would, ideally filling your peripheral vision with it. You can then *increase* the field of view again until you see the same thing in front of you that you saw on your smaller screen before at 60°.

Depending on how large your new screen is and how close you get, you can win a lot of periphery back, and

like in reality you will have to turn your head a little to see it.

At this point it will also become clear why iRacing distorts the larger field of view: if you get close to a big screen and you look to the sides, the flat screen will “negatively” distort the picture you are seeing, compensating for iRacing’s “positively” distorted field of view.



The second option is a little on the virtual side because it really doesn’t add anything to your field of view, but adapts what you see on your screen instead. The *NaturalPoint TrackIR* device scans your head motion while playing a game and interprets it as “looking into a direction”, turning the in-game view where you want to look. This means that if you want to see your right side mirror, simply turn your head to the right a little (such that you can still focus on your screen) and iRacing will tilt the view to the right and show you the rest of the

cockpit, eventually arriving at the side mirror if you just tilt your head far enough. This is a little like “driving with blinders” since you’re still only seeing a small field of view at any time, but *what* you see in that field of view can be changed as needed if you want to see what’s going on around you (much like you would in real life). Plus, the TrackIR probably costs less than a huge new screen or the final option!



This final option is what many enthusiasts go with, but it requires more space and a fast computer that is capable of providing three screens with graphics. If you keep your smaller screen that lets you see your focus view and add two equally sized screens to the left and right, preferably at an angle that slightly

“wraps” around you, you can actually get the real-world effect of peripheral vision back. iRacing will compensate for the angling of the screens with appropriate counter-distortion of the side views so that when you look at the angled screens, it will feel like an extension of the simulated world that fills your peripheral view. In the calculator, just enter the screen width including the bezel into the appropriate field and fill in the angle that you have your two other screens at.

This will allow you to see mirrors and other cars again while keeping an accurate, lifelike field of view on all three screens. Size, speed and distance will all feel natural while you won't miss the periphery anymore. In essence, this is the only way to drive a simulated car the way it should be done.

Unfortunately it costs a little bit of money to set up.

Conversely, you could use the same setup to play other computer games at a much more realistic field of view, with peripheral vision intact. For games such as shooters you would actually need to increase your *vertical* field of view too by attaching two more screens to the top and bottom of your main screen, running a cross of five screens total. But depending on the game, not even this much immersion might help if the designers scaled the size of objects inappropriately! This is why we will probably keep playing games with an unrealistic field of view that is at least “well done” by the designers to fool you into thinking it's correct. For racing sims, though, it can never be as good as a true-to-life representation.

Conclusion

I hope this slightly technical guide has shed some light on the field of view mystery and will provide lots of iRacers (and gamers in general!) with the info they need for a proper setup. Racing can be much more immersive in a simulation even without purpose-built cockpits only by adjusting a few parameters, as we have seen.

Good luck!

Picture sources:

http://en.wikipedia.org/wiki/File:Fisheye_lens_room.jpg

<http://en.wikipedia.org/wiki/File:Panotools5618.jpg>

http://commons.wikimedia.org/wiki/File:Portrait100mm5_6.jpg

http://commons.wikimedia.org/wiki/File:Portrait50mm5_6.jpg

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