Closed **SOFA virtual surround is amazing and you should try it!!**

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Closed Issue created 1 year ago by **pallaswept**

I was asked a question in another issue and I felt like this deserved a post of its own. If anyone's on reddit or whatever, please feel free to re-post this. I want to spread the word. The people who did this deserve recognition.

> May I ask have you compared sofa filter vs atmos, or any hesuvi file

This is a long post because the short version is that SOFA is absolutely amazing and I want to encourage people as much as I possibly can, to try it, so they can enjoy it like I am, and so they can appreciate the people who gave it to us like I do.

Perspective...

Before I answer this I'm gonna say, I'm a bit of an audiophile snob and strongly opinionated about audio quality. It's not a status or fashion thing or anything, just a consequence of circumstance. Like, I'm a fish snob, because as a kid, I grew up around sailors, so when I ate a fish, we caught it, and we took this live fish and beheaded and gutted and scaled it right there on the gunwales, and took it into the galley and cooked it and then we ate it while we fished for more fish. Every fish I ate was alive 10 minutes ago. So I got used to fresh fish and became a fish snob. It was the same for me with music.

I started out playing musical instruments at a very young age (3 - mostly classical and jazz and blues guitar, and a little drumming) and was really into physics and electronics, and it all blended together and grew into a strong case of audiophilia.

Later on I used to run a small recording studio, as well as a substantial home studio worth more than the house it was in, I've done professional PA setups for large concerts (and conferences), high-end car audio systems professionally (a side gig but getting paid nonetheless).... Before you could buy headphone amps, I built my own based on the schematics for the amp from one of my mixing desks, it was as big as a cassette Walkman and had a battery life of just over an hour or so because this was long before lithium or rechargeable batteries, and I used it to drive full-size over-ear studio monitor headphones on the move, and people used to stare at me because back then, people didn't do that (although it's normal now, wearing beats by dre would make you a freak back then) my portable DAP was the size of a small backpack, literally, I carried a backpack so I could play music on the move.

When I set up home hifi systems for myself or friends (they always ask me to do it) I take room responses and measure speaker distances to calibrate the speakers and tune everything perfectly, I generally use 5.1 (because practically nothing is a 7.1 or more source yet) but I don't ever use a single subwoofer, because I don't subscribe to the notion that low frequency audio is omnidirectional (fight me, Dolby! 😆), so all my sub channels are split into two subwoofers, so it's 5.2, 6.2 or 7.2 in all my gear, which usually means active amplification since most amps don't support that, and I don't do satellite speakers, all my drivers are full-range because I don't believe that just because it's on the side or behind me means I don't need to hear it all. Again this often amounts to multiple amps or active amped speakers.

I always tell all my friends to keep their speakers off the walls and off of cabinets and tabletops and away from corners and fill empty wall space because it all sounds cruddy, all my headphones are customised with special pads and tips and cables and all manner of stuff - although I don't go in for the stupid money grabbers like gold plated digital connectors (lol), or balanced cables for 1m long cable runs, that do nothing for quality at all, I do braid and solder and sheath my own cables to get the lengths correct for my body and the device, to avoid cable microphonics, and avoid ear fatigue...

....I'm an audio snob. So take my opinions from that perspective. You may think of this as over-cooked snobbery from some idiot who takes it way too seriously, or maybe you'll think this adds more weight to what I'm saying, maybe a little of both... that's up to you (and I take no offense either way), but I feel like understanding my perspective is important here, because I'll be rather blunt about it (although I removed expletives hehehe)

Observations:

Contenders:

Yep. I tried both atmos and hesuvi some time ago, a few times each over time, HeSuVi moreso, most recently a couple of years ago, when I was on Windows, and thought it was completely average at best, like all the other virtual surround solutions I'd ever heard. I was staunchly anti-virtual-surround, always had been, and try as I might - and I did try, because I believe in the theory that good quality virtual surround is 100% possible, I'd never heard anything that changed my mind. Even most true surround systems didn't do much for me, I mostly preferred good quality stereo (as in, two channel audio, but I didn't mind multiple speaker approaches to 2 channel, like quadraphonic speakers playing stereophonic signals) . I mentioned how I set up my surround systems but a great deal of the time they are only playing stereo, just three or four speakers per side.

The only superior solution I'd heard for virtual surround is in the battlefield game series starting from BF4 and the same tech in early BF1 (they broke it a little in later patches of BF1 and BFV was just ordinary), when they had Dolby engineers come on board at EA and they do a 360x360 degree practically infinite resolution sphere (pretty sure it's degrees measured in 32bit floating point, so... a lot of fractions of a degree (actually the math is easy 360/0xFFFFFFFF*2= 0.00000016763806346982 degree resolution)) of audio, and position every sound in the game according to the location of the model in the game, so it's like infinite speakers. That really blew me away, you could stand next to a static

Closed **SOFA virtual surround is amazing and you should try it!!** hear very clearly exactly where the sound was., and walk around with your eyes closed and tell how far you'd walked... it sounded real AF. They did a great job. There are a few similar implementations in games these days, because they can use the position of the in-game object as the source of the audio and it's all very precisely defined, so it was all about their algorithm for positioning, and naturally, Dolby are gonna kick some butt with that kind of thing. BF4 was ground-breaking. Not only in positioning but in occlusion and reflection (like the echoes of footsteps on hard floors indoors, or the sound of footsteps through a wooden wall vs through glass, etc)

SOFA:

But otherwise, I'd never heard virtual surround worth a damn. HeSuVi really improved a lot over the years (it's been around a LONG time now!) and to their credit, they've really got that going pretty well. No doubt, that takes second place. But it became a distant second when I read about the SOFA filter in pipewire, and thought, meh, I'll give it a try.... I'm always open to possibilities.... and I was ***b l o w n a w a y*** . Mind you, I spend an entire month finding the most correct model of my ears that I could out of the tens (hundreds?) of thousands of models freely available online - and **the model makes a BIG difference** (and I intend to make use of a tool that will take a 3D scan of your ear and make a model from that, when I have the time to get the equipment to take the scan) and two full days getting the speaker positions just right (which turned out to be *nowhere* near where I expected). But the results are just astounding. I was so amazed, I was like "holy cow, people need to hear this" but it's kinda like VRR monitors, or high refresh rate.... you can't demonstrate it without actually looking at the real thing, and you can't explain this without actually hearing it.... so I played it to a tech savvy friend to be like "how amazing is this", intending to show off the technology, and played helicopter sounds flying around him... and he's a war vet and I gave him a PTSD attack I kid you not. I'm *not* proud of that, it was a stupid accident and an absent-minded foolish choice for a demo sound, I'm a total frickin' idiot and I regret it terribly.... but it's a strong illustration of how real it sounds. He lasted about 3 or 4 seconds before he literally threw the headphones off his head and said, and I quote, "if this S### gets any better people are gonna end up killing themselves in movie theatres". And they were tuned for my ears, not his, so he wasn't even getting the full experience. With his hearing loss from artillery, not even close to the full experience. And his reaction was that strong.

Now I use it everywhere. My entire audio chain is surround, now. When I started using pipewire I was locked to stereo everywhere, unless it was a surround source playing to a surround speaker rig. If there was stereo anywhere in the chain, it was all mixed down to stereo at the source and treated as stereo throughout the entire chain. There are even posts on this issues log where you can see me talking about troubles I had locking it down that way. Now I upmix everything (a simple copy, no processing/filtering/delays/etc) because SOFA spreads it so perfectly that it doesn't distort the quality of the audio, which is a big deal to me as a musician and music lover. Usually virtual surround of upmixed music sounds like trash, the frequency response is all messed up and you lose a bunch of sound and it boosts certain other sounds... Hi-hats are super prone to distortion, guitars lose their tone, orchestras lose their depth and dynamics (that's one of the strongest ill-effects I find).... SOFA doesn't do any of that. You just feel like you're literally sitting in the middle of the band or orchestra sitting in a circle around you facing inward, like a reversed concert stage. I have a 5.1 recording of a concert I attended and it literally sounds like being there, it's amazing.

The only thing it's missing is a good tool to mix it with head tracking - and such tools DO exist, but they're a bit hard to set up, so I haven't done that yet, but I'm going to do it. Because the positioning is so strong that you feel like you can't move your head at all, or the whole 'world' in audio moves with your head and it's just bizarre to the brain.

But it's just amazing, there's a mind-blowing number of models available - which is a blessing and a curse, because you DO need to find the right model for your ears/head, to truly benefit from it, and it's like finding a needle in a haystack.... but pipewire's implementation makes it so easy to get it *just right*. Once you find the model, you just have to get the speaker positions *just so*, and it's literally just punch in the angles, really simple stuff.

I really want to encourage people to put in the effort - and it is a fairly considerable effort to be honest - to try it out, so they can experience it, and so they can appreciate thee amazing work that all the people involved have done - from uni nerds doing doctoral theses and publishing their models, to programmer nerds at pipewire making it a thing we can all experience, these people have done something amazing and I want everyone to know about it and to feel the enjoyment of it and to feel the appreciation for these people. I feel like nobody is talking about it and it's as if I'm the only person in the world who has ever eaten chocolate, I just want to give everyone a block of it and be like DUDE HOW AMAZING IS THIS?!

To quote my build instructions for my PC, just me thinking out loud to myself in a commented-out line

```
# These people amaze me
```

And I want everyone to know about it. Pipewire+SOFA is the absolute duck's nuts.

No child items are currently assigned. Use child items to break down this issue into smaller parts.

Link issues together to show that they're related. Learn more.

Activity

- **pallaswept** mentioned in issue #3606 (closed) 1 year ago

JustCauseWhyNot · 1 year ago

How do you know to get the speaker positioning right? And maybe silly question, but for games would 5.1 or 7.1 be the correct channel configuration?

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Author

TL:DR trial and error, and either 'headphones' in modern games, or whatever the game's maximum is - and PS, EQ the stereo headphones in stereo, *after* virtual speaker positioning.

The speaker layout was literally trial and error. I started out with the standard Dolby positions for 5.1 https://www.dolby.com/about/support/guide/speaker-setup-guides/5.1-virtual-speakers-setup-guide/ they have guides there for all their standard layouts, so if you want to go 7.1 or 9.1 or 3.2 or whatever, they have that too: https://www.dolby.com/about/support/guide/speaker-setup-guides/ all the angles are there in pretty pictures, it's a great starting point at the very least.

The pipewire config files use the `azimuth` parameter, and it is measured starting at 0 degrees being directly front and centre, and they rotate clockwise around to 360 degrees just like a compass. So for example if you want 30 degrees to the left of centre, that's 330 azimuth. You also get `elevation` where 0 is front, 90 is above, 180 behind, 270 below you, and radius, which is the distance to the speaker in metres. I found that not all sofa files supported all radii or angles, so it's something you should consider when searching for the right model. Very many of them have a fixed distance, and quite a few do not go directly below you, for example. It's an artifact of the way the impulses are recorded. The information pages for many of the model collections, generally will have some information as to how they set up the recording, and it will give you a hint about what will work and what will not. If you set a position that the model doesn't support (like, directly below you where the model was generated by a human sitting in a chair, so they couldn't put speakers under the ground the person is sitting on) then you will just get silence from that virtual speaker's channel.

There are a zillion things you can use to test it out, but if you have access to this film in surround sound, the very first seconds of the film "Apocalypse Now" are a great test. Just as the movie fades in from black, a helicopter flies behind you from right to left, turns right, and then flies across the front of the screen from left to right. So it kinda flies a circle or a horseshoe shape around your head. When your speakers are "right", it will be a perfect, smooth transition, but when they aren't, it will fade in and out at the wrong places.

I just played that scene like a bajillion times, each time moving the speaker angles in my pipewire config file, until it sounded like a perfectly smooth transition. It was then that I realised why it didn't work out like the standard Dolby 5.1 layout - it was clearly recorded with the intention of being listened to in a cinema, and basically, from the centre seat. So, you've got a bunch of speakers behind you. Having them behind me worked well for me, but I'm very sure it will be a matter of personal taste. I think the purist approach would be to use the exact recommendations of Dolby and expect the movie to be accordingly mixed. Movies are often re-mixed for the DVD/BD release so it's entirely possible that different movies will work out differently, so I's certainly recommend trying others, too. But that scene is super useful.

I also found these files very helpful as generic test files: https://archive.org/details/5.1SurroundSoundTestFilesVariousFormatsAACAC3MP4DTSWAV (Donate to archive.org! They're literally saving the internet 😆) Not all of these are actually surround, you'll know when you try them which ones are the most useful. You can download them and put them in your media player and loop them or whatever, too. very useful.

But in the end, I settled on something WAY different to the Dolby layout I had anticipated would be correct. My rear speakers ended up literally behind me (on either side), at the same angles from the centre, as the front speakers. I had assumed that since most footage was recorded or mixed with the Dolby positioning in mind, that would be perfect first shot, but when I tried it, I moved them around back and forth and found that spreading them fairly evenly around me like a big X sounded nuts. So that's how I kept it.

In the end, I wound up with the front speakers 30 degrees either side of centre (so 30 and 330 degrees) and the rear speakers 30 degrees either side of behind me (so 150 and 210 degrees azimuth in the config files). Naturally the front centre speaker was at 0 degrees, front and centre...but the sub....the sub i put at 180degrees - directly behind me and an elevation of -45 degrees. So the subwoofer effect booms literally kick me in the backside. It's completely bizarre and in a real world it wouldn't be possible without digging a hole in the floor behind the couch, but with this it was not only doable but I loved the effect so I kept it. I never intended to keep it, I was just curious if I could do it, Funny how that worked out.

Highly non-standard and not necessarily a recommendation (but by all means, try i if you like!), but just a demonstration of how experimentation can lead you to strange unexpected places (like under your own butt 😆)

For games, if they are modern games with a headphone setting, use that, and don't use any virtual surround treatment at all, it'll be doing it's own, in-game. It'll use HRTF psychoacoustics like I mentioned above and be like infinite speakers, there's no speaker count that can ever match it. Lots of shooter games have a 'test range' or something like that, where you can go and just goof around with different weapons and targets and stuff, that's a good way to test it out.

Otherwise, as always, it's a matter of "the more speakers the better" - so long as they're really positioned there (virtually in the game world) - as in, so long as there really is a source with that speaker count. Choosing 7.1 speaker setups if the game (or movie or music or whatever the source is) only supports 5.1 sources will only serve to provide inaccurate positioning.

Although, there's no reason not to make multiple virtual speakers for the real sources. Since I use 5.1, I'm strongly considering placing copies of the speakers above- and below-level, so the 5.1 will become effectively 5.5.2..... because I can. I have no freakin clue how they make it do this with such a low CPU draw, but it's highly efficient. Low single digit percentages of the CPU at low clock speeds, sort of scale. Insignificant. Likewise, you could double them up laterally rather than vertically, and make a 10.2 setup, so it

will be like each speaker is twice as wide. or heck both, and have 10.10.4 Whatever takes your fancy, it's all possible. Just stick to virtual speaker layouts which match the source material - although, pipewire will upmix it if you don't... but it wouldn't give the best positioning.

Keep in mind, once you've done the hard part of finding the right SOFA model, you can go ahead and create as many different

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ll just using that same SOFA impulses, and direct your game or application as appropriate, in accordance with whatever sources it provides. Pipewire is smart and won't waste CPU time on the ones you aren't using (they will become idle and disable themselves), so there's no harm in it at all.

One thing to keep in mind is headphone EQing. If you're going to use some kind of EQ like for example the amazing https://autoeq.app/ , that should be placed in the filter chain AFTER the SOFA positioning is mixed down to the stereo signal ready for headphones. If you put it before the positioning, the effect the positioning applies will be applied to the EQ'd signal and the result will be inaccurate.

pallaswept closed 1 year ago

DarkSwan86 · 1 year ago

@pallaswept thanks for this post! Very motivating to try SOFA on my setup but, alas, i have some problem configuring it (see my ticket #3722 (closed)). Can you help me try to setup it? Thanks!

pallaswept · 1 year ago Author

Hi @DarkSwan86 I like your name. The Black Swan is the official State bird of Western Australia 😄

Sorry I didn't help out with your issue sooner. I generally try to keep an eye on the new issues and help out wherever I can, but I've been super busy lately and I missed yours. I'll respond to it right away!

DarkSwan86 · 1 year ago

@pallaswept finally fixed now everything works. Now i have to find out the correct model to use. Any suggestion how to find it? There are any info on that databases that can help me find the right one (ex. anatomy of the ear, measurement,etc...)?

pallaswept · 1 year ago Author

Great news!

Yeh, finding the model which matches your head and ear is the trick to making it something really special which stands out from other virtual surround solutions. It's also somewhat difficult - this is the 'catch'. But it's all worthwhile when you finally hear the fruits of your labour.

If you start out at this page there you'll see a full list of all the collected sofa impulse collections from various projects.

Each project has a brief description of how they captured the impulses - perhaps they used a stationary mannequin and a single moving speaker, perhaps they used an array of many speakers from many angles, perhaps they used a robotic arm which moved a speaker or array of speakers around the microphone, perhaps the microphone was not on a mannequin but on a real person's head or inside the ear of the mannequin or human, perhaps they used a single pinnae (outer ear) shape from a standard model, or perhaps they used 3d printed artificial pinnae, etc, etc.

But these are just brief descriptions of the methods used, and don't contain the details (or often, any of the details such as those I just mentioned) which you need, to find your 'match' - to get those details, you need to visit the page of each project, linked on that page. Firstly you need to make sure that the speaker positions supported, will match the speaker positions you want to use in your virtual speaker positions. For example maybe it is important to you to have multiple distances of speakers, or to have speakers beneath you, or something specific like that. Secondly, you want to make sure that the sound sources they used to create the models, are close to a representation of the kind of sources you might listen to.

But the big one that makes the most difference between models, is pinnae shape. PRTF > HRTF. For example there are several projects which use the KEMAR dummy head and its standard pinnae, so the only difference between those models is their method of positioning the speakers, the microphones they use and their positioning (behind-the-ear, in-the-ear,etc), etc, some projects only model certain limited audio frequency ranges, etc.... and while these results are very useful for discovery and refining techniques for furthering the field of research of auditory perception, for our purposes, the returns in searching through those are small.

However other projects will use various head sizes and shapes of head and ear, along with their specific unique speaker/mic configuration, and those are the ones which are worth digging though.

To give an example of each type, the first type, the "good for research, not for listening" type, would be something like this one:

- THK/HRIR_*: HRTFs of various mannequins provided by the Technische Hochschule Köln (TH Köln, previously Fachhochschule Köln); further details can be found here:
  - Far-field HRTFs: Gapless data, high spatial resolution HRTFs of Neumann KU 100. Files: HRIR_CIRC360, HRIR_CIRC360RM, HRIR_FULL2DEG, HRIR_L2354, HRIR_L2702.sofa *(Credit: Benjamin Bernschütz, Germany)*.

- Near-field HRTFs (HRIR_*_NF*.sofa): High spatial resolution HRTFs of Neumann KU 100 done for various distances *(Credit: Johannes Arend, Germany)*.
- Head-gear HRTFs of Neumann KU 100 and HEAD acoustics HMS II (KU100*.sofa, HMSII*.sofa): High spatial resolution HRTFs while wearing various head gears *(Credit: Christoph Pörschmann, Germany)*.

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hose last three links there are PDFs which describe in great detail the techniques used. You can see that they are using a limited number of standard model human subjects (mannequins, all with the same ears), and also for example the near-field HRTFs use a sound signal which is high-pass filtered above 200Hz - meaning, they never did map out what it does to bass. Not really useful for a) matching our sound sources or b) matching our bodies

One the other end of the scale are projects like this one:

- Widespread (Wide dataset of ear shapes and pinna-related transfer functions obtained by random ear drawings): 1005 pinna meshes matched with correspondingly calculated PRTFs from the FAST team, IETR (CNRS UMR 6164), CentraleSupélec. The meshes were created by varying principle components obtained from an analysis of 119 pinna meshes of actual listeners. The PRTFs were calculated by means of the boundary-element method for two spatial grids and three distances, see the upcoming publication (documentation). *(Credit: Corentin Guezenoc, France)*.

This one is something of a research project, in that it does not physically play sound and record it in order to generate the SOFA impulses, but rather, uses mathematical functions to virtually generate such results - however, it does have the advantage of using a VERY large dataset of pinna shapes, which has been growing over the years, as they take measurements of more human ears, and then collect them and feed them through their algorithm to generate results. So, this can be a very interesting project if you're having trouble finding matching pinna (I certainly did - I have weird ears! 😆)
Reading through their documentation provides some screenshots of the 3d models of different ears, but the entire dataset of literally thousands of ear shapes (which is exceedingly unusual, keeping in mind that at least half of these projects use ONE), are available as STL 3D models, along with the corresponding SOFA files.

Similarly, there's this project:

- VIKING: Full-sphere HRTFs (.sofa) from the Viking database. KEMAR mannequin with 20 different pairs of artificial silicone pinnae attached, plus a "pinna-less" condition, measured for 1513 different directions. 3D scans of left pinnae are also included (.stl). *(Credit: Simone Spagnol, Denmark)*

As you can see from the brief description, this is a fairly high-resolution positioning of sound sources, and done across a set of 20 different ear shapes, and once again, all of those ear models are available as 3D models in STL format - although they do have photographs of those 3d-printed copies of real human pinnae, in their PDF documentation. So, this project has a wider selection of ear shapes than most, very high positioning resolution, and (as you can read about in their PDF) reasonable audio resolution (they measure from 100Hz to 16KHz in 100Hz steps). There are several others with better audio quality and more ear shapes to choose from.

So basically, you just want to start at that first link, read the brief descriptions and use those to filter out some (easily half) of the projects, and then if the brief description holds some promise for your criteria, follow the links to read deeper into the projects methodology, and if it still looks useful, get some of the data, like photos of subjects, 3D models of pinnae (be they real human, 3d printed from real humans, 3d printed from randomly generated measurements, or whatever), the recording methods used (sound frequencies, speaker and mic positions,etc).... and just keep on filtering down the list by a process of elimination.

You'll end up with a shortlist of several sofa files, and then you can put them in your pipewire config and give them a try, give each a trial run with some sensible standard speaker positions, and you will be able to hear which ones have the greatest and most realistic effect of the sound moving in space as it emanates from different virtual speaker positions..... and then as the finishing touches once you have decided on the most effective and realistic model for your individual person, tweak the speaker positions to be just right, and you're all done.

I won't lie, it's a chore, it's time-consuming and a little boring at first... but once you get that short-list of files and hear it in effect it definitely leaves you feeling that the investment of time and effort was very much worthwhile. Once you do that final step of positioning the speakers perfectly, and take the time to watch a movie or cencert or something in surround format, it is truly mind-blowing, and I'm sure you'll feel it was well worth the effort.

A tip to make this easier on you: When you write your pipewire config file, when specifying the location of the SOFA file, point it at a symlink, and point the symlink at your SOFA file. This wa,y rather than having to search+replace several instances of the sofa file path, in your however-many config files, you can just change the target of the symlink in one place, restart pipewire, et voila, ready for the next test. It's a big time-saver.

DarkSwan86 · 1 year ago

@pallaswept thanks soooo much for all these informations and the trick for the symlink! Time to test!

BTW this should be in a wiki on pipewire manual, it's so detailed, it's a waste lost here on the bugtracker :)

Just asking one more suggestion: i think that i will use the Dolby Atmos "Amaze" trailer (Dolby Atmos track inside, tested quickly, during the 360 surround bird flight i can ALREADY hear the difference, switching from the Spatial Sink to headphones from the sound taskbar on KDE...the sound it's truly different!) to find the right SOFA file, but i need something very spatial as movement, quite short so i can put it in loop during the tests, while i switch between the SOFA files. Do you have any source or suggested files?

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pallaswept · 1 year ago

Author

If you want the TL;DR, jump to the last paragraph :)

I found a copy of that 'amaze' trailer on this website, it was pretty cool :) They have a whole *bunch* of trailers there that would be good for testing, and they're all free for download, so that might be a good spot to look for stuff.

I'm only using 5.1 not 7.1, so I'm not sure that my test files will be so useful for you, but perhaps they'll give you an idea of what's useful, so it will help you find something equivalent in 7.1. I had two that I used primarily for that "quick test on a loop" thing you're talking about. The first was this one which came from a page of 5.1 test files on archive.org (PS I wouldn't click on the links in the 'reviews' on that page, not sure they're safe...). There are similar kind of files available here: https://www2.iis.fraunhofer.de/AAC/multichannel.html - specifically the one at the very bottom of that page seems to be a good one, and it's 7.1.

If you download the files and play them with a local media player (I used haruna which is a front-end for MPV and I have found to be an excellent media player, and it has native pipewire and Wayland support, so it 'just works' where VLC sometimes doesn't, if you're on Wayland too) you can also set up a loop of parts of the file so you can bounce between channels, like just play the "front right...rear right..." over and over. Can be handy for distinguishing between the front and rear channels of the same side.

My absolute favourite might be harder to come by. I own it on DVD so I had a copy in 5.1 already, but I don't think you'd be able to download it (legitimately...). The latest revision of the film has been totally remastered and very likely has a 7.1 soundtrack available, too (I haven't been able to find it to buy, yet, without having to buy a standalone blu-ray player, and I love that movie, but not $500 worth of love hahaha. They really need to make blu-ray work on PCs! But I digress...) But anyway, perhaps if you can find a copy, the opening 30 seconds of the movie 'Apocalypse Now' are easily my favourite for testing.

The movie opens without any credits, fading in from black, and there is a helicopter which flies behind the camera (you) from right to left, turns 180degrees to its right, and then flies forward, across the front of the camera.... so it flies a circle (or technically, a sideways 'U' shape) around your head. I found it really good for getting the speaker positions just right, because it *almost* fades out completely as it flies away to the left, before it turns around, and only when your speaker positions are *just right*, will it sound like a smooth transition from one speaker to the next and not jumpy or dropping out or anything. Being a helicopter and turning and then making a flyby, it also has a full range of audio frequency from high to low. Very handy.

The TL;DR:

So I guess the point of what I'm getting at here is that what you want are two files - one which specifically plays audio one speaker at a time through each of the speakers, so that you can test the effect of the virtual surround, that it really does sound like it's coming from whatever position you have set in your pipewire config file (the `azimuth` property). Especially, this is going to be about making sure that the side speakers sound like they are coming from the side, and rear speakers sound like they are coming from the rear, and you can distinguish front from side from rear. The better the match of the SOFA file to your person, the more clear distinction there will be. Then, you want another file with a constant sound that smoothly rotates around a circle around you, so that you can fine-tune the position (`azimuth`) of the speakers, such that the circle *sounds* like a circle, nice and smooth, without any 'bumps' or 'dips' or 'jumps' in the sounds volume or position.

Hope that helps!

Edited 1 year ago by pallaswept

Please register or sign in to reply

JustCauseWhyNot · 10 months ago

What am I doing wrong if anything that when using sofa it sounds like I'm listening to it through an underwater filter? Here's my pipewire setup. I'd appreciate any help you've got to offer. The positioning of the sound seems fairly accurate, but the sound itself is lacking a lot of lower frequencies.

JustCauseWhyNot · 10 months ago

Would you happen to know where I can find stl's of the widespread database? I can't find any, and I really don't wanna trial error all of them.

JustCauseWhyNot · 10 months ago

What is a properly working sofa file supposed to sound like? There's just so many differences that I'm just confused on how

to a/b test them.

pallaswept · 10 months ago Author

I'll start with a TL;DR because I go into a lot of detail here. Nobody else is talking about how to use this feature, so I want to

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TL;DR:

1. Check the method used to record the impulses and create the SOFA files (usually documented on a website or PDF) - the best they can record with their setup, is the best you will hear when using their SOFA files. Bad mic quality? Bad output quality. 'Noise' frequencies filtered out? Those frequencies are inaudible over virtual surround. Speaker array doesn't extend to that position (angle or distance)? Virtual speakers placed there are silent. All common, and bad for us.
2. Beware mis-mixed/empty channels.
3. Don't use Firefox for testing, its audio stack is busted.

Bonus PS (re: widespread):

1. f3d is a very handy viewer, it loads the STL's fast enough that you can functionally scroll through 1000's of them to search/compare.
2. stl-thumb is super handy since it integrates with your DE/file manager.
3. Because widespread impulses are artificially generated, they do not suffer the limitations of recording setup, so they have highly accurate reproduction (good for music! plenty of bass.) They also do not capture the subtle nuances of a mic recording real, physical position data, so their surround positioning, while entirely adequate, is not as well-defined as the best impulse sets. I feel this is a worthwhile trade-off.

> What is a properly working sofa file supposed to sound like?

Like you are hearing the thing you are playing, and you are there live at the moment it was recorded, and you have put your head where the microphone(s) was(/were) during recording.

But don't be put off if it doesn't sound like that at first. It might take some tinkering.

Details

> What am I doing wrong if anything that when using sofa it sounds like I'm listening to it through an underwater filter?

I can relate to this...

> The positioning of the sound seems fairly accurate, but the sound itself is lacking a lot of lower frequencies.

...and especially this. I had this exact problem. Everything else was like hearing with super powers, but there was no bass whatsoever.

I found two things contributed to this problem. One was the SOFA impulse I'd chosen. If you check out the attached documentation of the research or project that has produced the files, it generally will give a hint about the capabilities of the impulse - **the resulting audio quality will always be limited by the process they use to generate the impulse.**

Garbage in, garbage out

So, for a simple example: if they filter out all sound below 50Hz in their recording, for noise reduction, then the resulting impulses instruct pipewire to filter out everything below 50Hz...

Usually the project will detail their process, so you can just read the PDF/website and know what kind of mic they used, what speakers, how many, what moved, what didn't, how far, what was recorded, what was filtered out, etc, etc.

For example:

> - ARI: HRTFs from the ARI database. In-the-ear HRTFs and DTFs for over 220 listeners.
>   - hrtf, dtf: HRTFs and DTFs, respectively, equalized between 300 Hz and 18 kHz
>   - hrtf b/c, dtf b/c: HRTFs and DTFs, equalized between 50 Hz and 18 kHz for hi-fi auralizations ("b" and "c" differ each other only in their starting positions and the order of measurement positions: b: 0°→0°, c: 270°→270°; direction always clockwise ↻)

This set sounds good for positioning and all, but that first set is useless for bass since everything below 300Hz is poorly reproduced, if at all, and the second set being specifically designed to fix that, is a lot better, but still not great. 50Hz kinda misses a lot of sub-bass.

One impulse I tried seemed really good for position and clarity, but they ran a highpass filter with cutoff frequency at 150Hz, to remove machinery noise from their setup (robotic speaker recorded from a stationary chair) - so the result was that the impulse didn't handle anything below 150Hz, so, no low bass would be heard at all..

I found one which was recorded in 2 dimensions, so cut off my speakers if I used any height. Since I *was* using height, applying that impulse made 4 of my virtual speakers stop working. There was no error or anything, just no sound - which is the correct behaviour, but it was tricky to figure out why.

As well as using angles supported by the impulse, distance to the speaker has to be supported. I have one here I like but it

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n. They can be choosy.

Channel Mixing

There is one other issue I know of, which really screws with things, and that's channel mixing. The virtual surround configs really *expect* (I mean, they *need* it) surround content, because the positioning of the speakers is taken care of by the SOFA filters, but there is no 'room' in this virtual world, so there are no reflections, it sounds super sterile and ...IDK, just wrong. If you play sound through the virtual front speakers only, and leave the surround virtual speakers silent, then what you hear is like speakers in The Matrix or a concert at a football stadium made of cotton wool, it almost sounds 'right', but, very 'uncanny valley'. It's not good. Adequate for carrying speech, but very hollow-sounding and definitely no good for music or HD movies.

Upmix to the rescue

This should not be a problem, you can just allow pipewire to upmix stereo content, and it works out great. For a more audiophile-friendly, purist approach to this, you can fiddle with pw's channel mixing to make it just do simple copy and summing of signals, without any filtering or phase shifting or delay effects.

Normally, apps which play in stereo, will be upmixed by pipewire, and the front speakers will be copied (possibly with some modification along the way) to the rear, side, centre and LFE channels. When you play all of them via virtual surround, the sound all reaches your ears in the end, and you hear it in stereo, with a very distinct soundstage: a well-mixed song will sound like you are either on stage among the band, or front-and-centre in a small amphitheatre with them singing only to you. Songs with attention to detail in the stereo field will achieve a real '3D' effect, without negatively impacting sound quality (which I'd have said wasn't possible but here we are...). Solo, mono voices just come out everywhere and the result is that the voice seems to originate at the centre of your head. It's odd, but cool, and it feels intuitive and 'normal' and no 'uncanny valley' effect.

Firefox

Firefox totally breaks this. It has a bug where, if playing content with channel count mismatching the sink, Firefox assumes the channel layout of the sink rather than the content, meaning it plays stereo content in stereo, but also creates surround channels, and then plays silence into them (rather than just not using them at all). The result is that pipewire sees a surround signal, doesn't(/can't/shouldn't) upmix, and the stereo channels are sent to the virtual front speakers and the remainder left playing silence and the result is...very thin. You're supposed to be hearing 6 channels worth of volume and you get 2.

At present the only workaround for this is to manually re-map the channels from Firefox to the sink, to do your own crude upmix. Which has to be done by hand every time you press play ☹ A FF dev did ask a few questions about it recently, so perhaps it might happen before too long 😃 In the meantime, test with chrome, or better yet, a good movie/music player. If you find a sound test online that you like, download it and play it from local file with your media player, and it'll sound much better.

Widespread

> Would you happen to know where I can find stl's of the widespread database?

They're with the database 😄 `pinna*.stl` is the filename there. The PDF describing it (as per the above) is there, too. Some interesting details taken with that project, like, the impulses are created by placing a virtual speaker at the listener's ear, and surround them with mics (which is the reverse of the common and intuitive way, of having mics at the ears, and either an array of speakers, or moving the listener or speaker(s) with robotics). I can't find an archive of that project, so, you might like this:
`wget -r -np -nH --cut-dirs=2 -R --retry-connrefused --wait=2 --random-wait -nc ``https://sofacoustics.org/data/database/widespread/`
That'll download the entire thing. Run it from inside a directory you want to download to, if there are errors, just delete any corrupted downloads and run it again. You'll need 108.2 gig free, it's BIG! (3.5G just for the STLs - maybe worth downloading everything *except* the actual .sofa files (`--reject "*.sofa"`), choosing the impulses you want by the stl, and just getting those individually? That's what I would do, if I had the chance to do it again. Now I have to find 100G to store this, lol)

FWIW my experience with widespread is that the reproduction is mint, and the positioning is not as good as the best. It's pretty much my favourite, but I haven't settled on one model yet (I have a few in a shortlist). It makes me really want to get a 3d scan of my own ear and synthesise the SOFA model like they have. There's another project which also generates SOFA impulses from 3D scans of pinnae, on github... A rabbit-hole for another day, I think!

JustCauseWhyNot · 10 months ago

Thank you very much. I've also found widespread to give me the best results. I've not found a perfect one, but 00027 seems to be pretty accurate. There's still a bit of a weird effect, but it may just be what virtual surround sound is going to sound like.

> It makes me really want to get a 3d scan of my own ear and synthesise the SOFA model like they have. There's another project which also generates SOFA impulses from 3D scans of pinnae, on github... A rabbit-hole for another day, I think!

I'm interested in that as well. I'm guessing you're referring to mesh2HRTF? It's something I'd like to do in the future.

Also would it be weird if I find the positioning to be accurate with this config?

▶ **config**

I'm not sure how exactly I should run a test in a game. The game I'm mainly playing right now is warthunder, and it's got a lot of

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pallaswept · 10 months ago

Author

Yeh mesh2HRTF seems legit?? 🤷

> would it be weird if I find the positioning to be accurate with this config?

I hope not, because that is a LOT like mine 😁 Mine's basically that, with the two speakers on the sides missing.

You might have trouble with that LFE elevation and some models, but it's probable that widespread won't care (to be certain, I'd have to read their docs again, and I'm not doing that lol) . Try it with most of them, and everything will seem to be working OK, but if they didn't have a mic there or whatever, when they recorded it (eg: -60 would mean something like a chair suspended above ground with the speaker array extending below it - difficult, expensive, and uncommon) then the audio that goes into that channel will be silenced.

Edited 10 months ago by pallaswept

JustCauseWhyNot · 10 months ago

Alrighty. Good to know I've got it setup prob the best I can. Thank you very much for your help.

JustCauseWhyNot · 10 months ago

> to be certain, I'd have to read their docs again, and I'm not doing that lol

What would I be looking for in the doc?

pallaswept · 10 months ago

Author

Something about whether they had mics or speakers in the appropriate positions (virtually, in the case of widespread) to generate impulses for that position - if they didn't record there, you can't play back there.

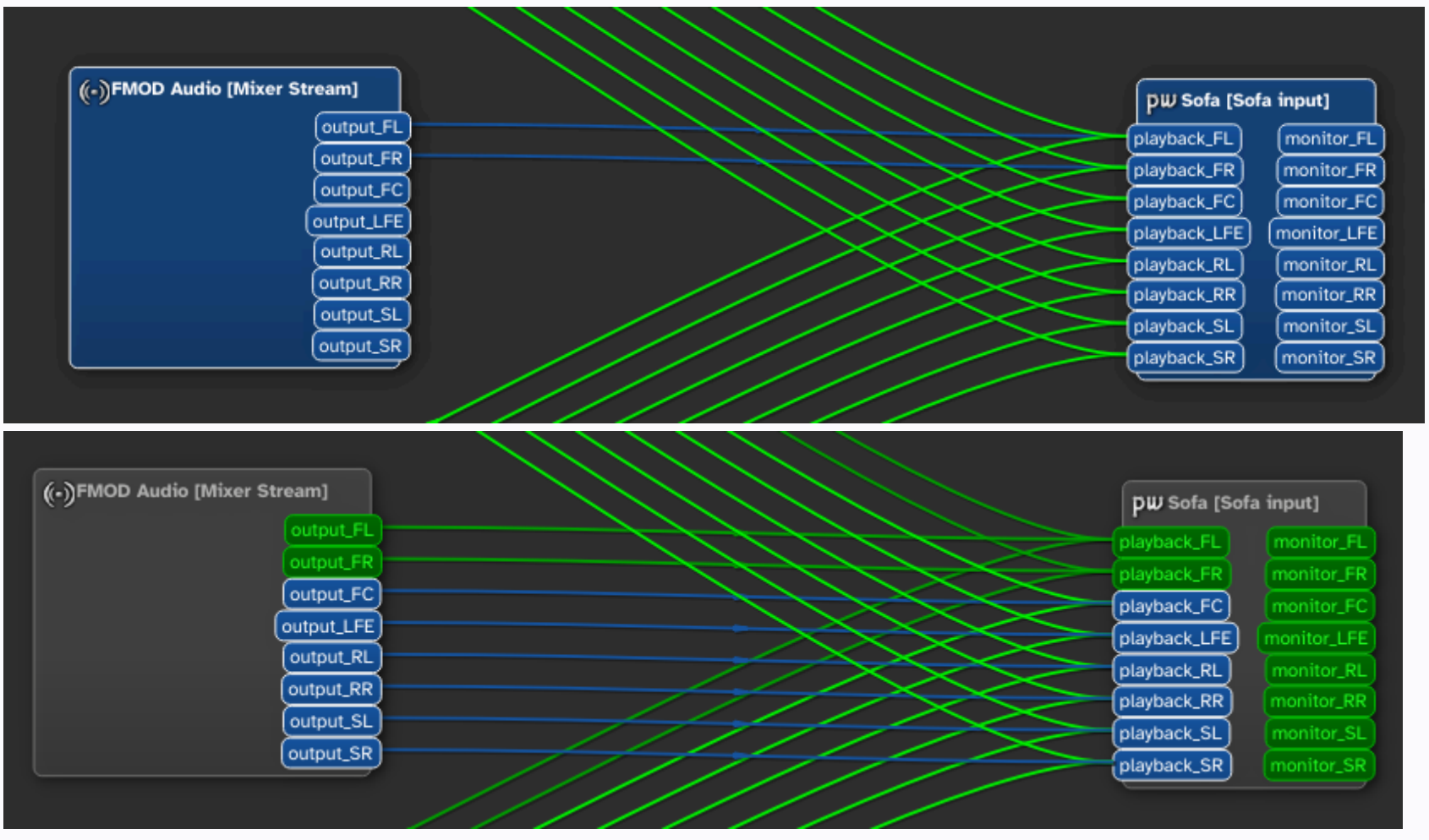
For you, though, it's easy - just go into your pipewire patchbay (qpwgraph/helvum/qjackctl/whatever) and unplug the other channels to see if your LFE channel works.

JustCauseWhyNot · 10 months ago

So disconnect everything except for lfe? If I hear sound does it mean it's working correctly then?

I notice no sound if I disconnect all but lfe. I'm guessing that means it's not working?

I actually don't notice much if any difference between these 2 images.



Edited 10 months ago by JustCauseWhyNot

JustCauseWhyNot · 10 months ago

Is there something not working correctly if there's no sound from every channel but FL,FR?

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pallaswept · 10 months ago Author

Hmm yeh, that seems broken. Out of the box, pipewire upmixes where needed (eg when playing stereo sources to a surround sink), so even if you're only playing stereo, it should be in 7.1 by the time it reaches the sink.

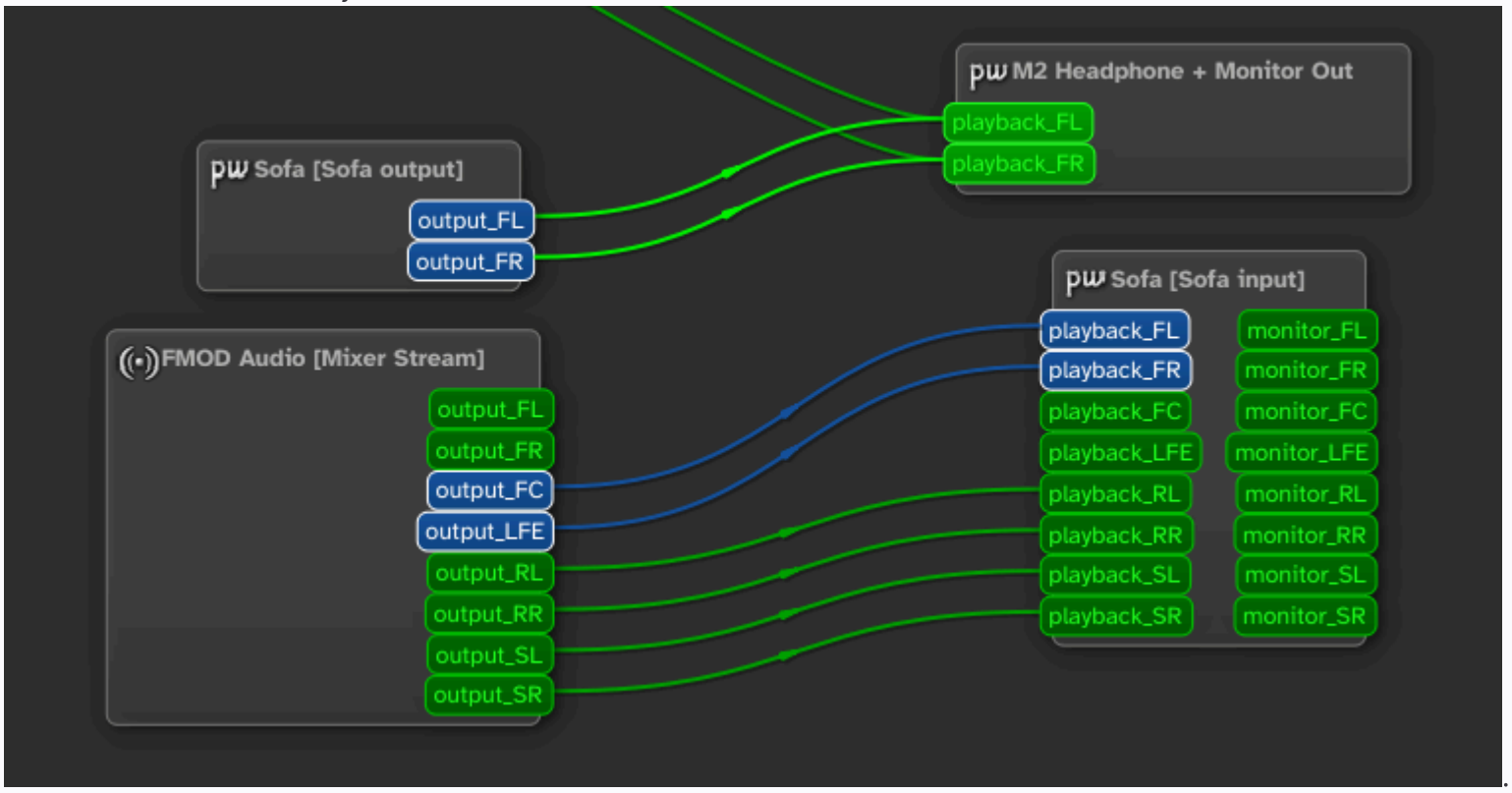
Try wiring it up differently, to see if there's audio in the channels (eg wire the S[L|R] / R[L|R] channels from the player, to the F[L|R] channels on the sink.)

That bug I mentioned in firefox, has been seen elsewhere (the official but unsupported linux spotify app for example), so it's possible you've got another example there. FF does exactly this (plays stereo+silent channels, instead of the normal surround with full channels or at least stereo fallback. It plays incomplete, broken surround.)

... So you need to find out if it's the client or your sink or your pipewire channel mix config. GL mate!

JustCauseWhyNot · 10 months ago

There is no audio from any of the other channels.



. What in my config is wrong? Thank you so much for your help.

pallaswept · 10 months ago Author

Your config looks OK. You've made it very tidy, and I didn't notice anything that might do this. MAYBE this

https://github.com/JustCauseWhyNot/dotfiles/blob/ca50bfdc6db5d281a9e022988c4ecbe63dd95f33/.config/pipewire/pipewire.conf.d/30-eq.conf#L18

But it seems like a player bug maybe. Haruna has been very reliable for me in my testing, maybe try that? (mpv is its backend, so that would be the same)

JustCauseWhyNot · 10 months ago

I will test that out to verify its not a pipewire issue. Also to confirm I don't need a 7.1 recorded file, but instead anything will work right?

Edited 10 months ago by JustCauseWhyNot

JustCauseWhyNot · 10 months ago

I downloaded a random video, and watching it through mpv I'm encountering the same issue. No sound from any other channel besides FL,FR.

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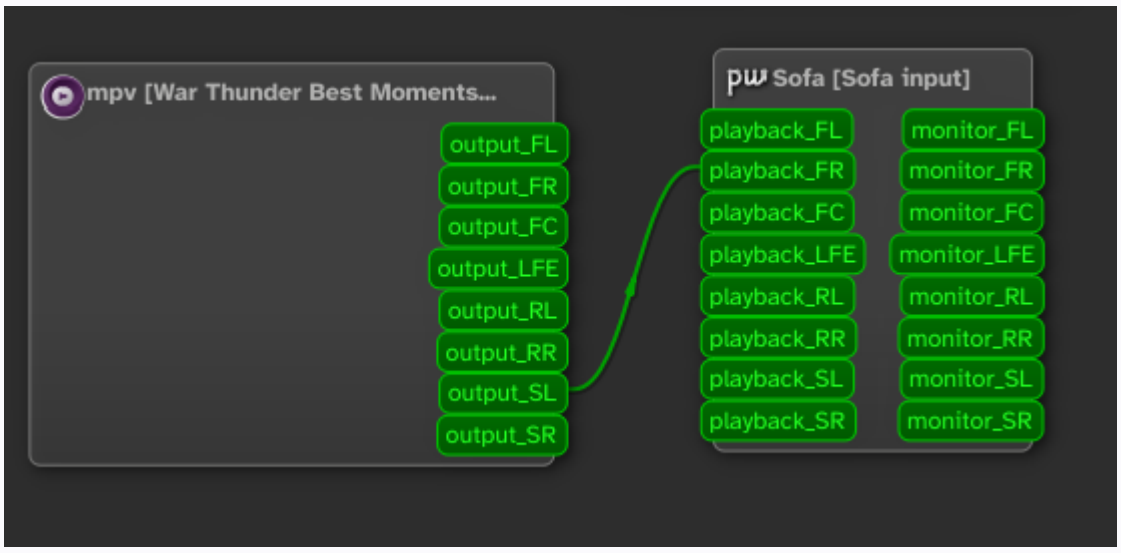
Sound 

No sound

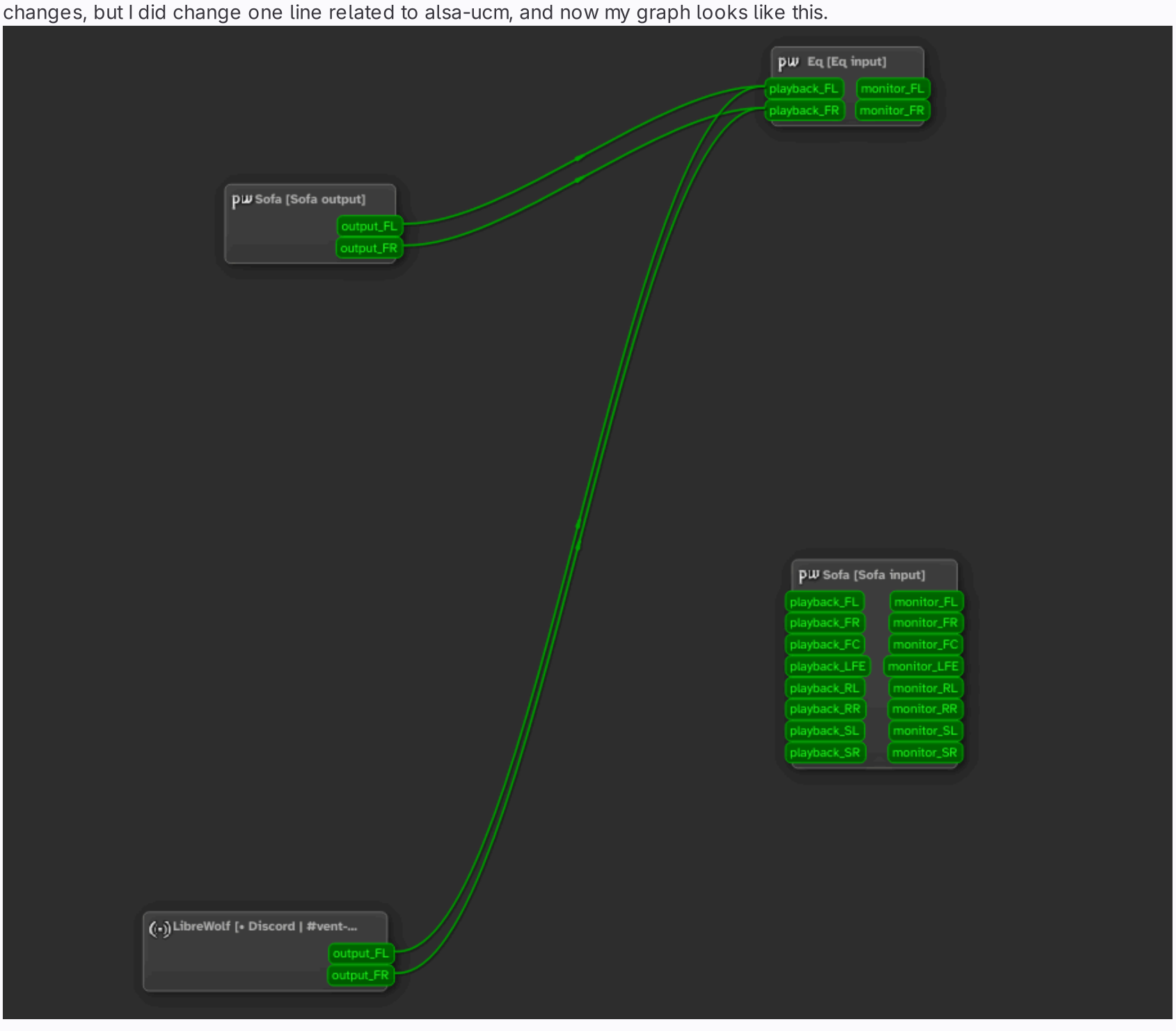


pallaswept · 10 months ago Author

What happens if you connect mpv's surround outs directly to your sound card, rather than the sofa filter? Can you hear those channels then?

JustCauseWhyNot · 10 months ago

I'll test that out, but currently I'm having an issue. I deleted my /etc/pipewire, and /etc/wireplumber since I didn't make any real changes, but I did change one line related to alsa-ucm, and now my graph looks like this.



Ok I fixed that little issue.

Edited 10 months ago by JustCauseWhyNot

JustCauseWhyNot · 10 months ago

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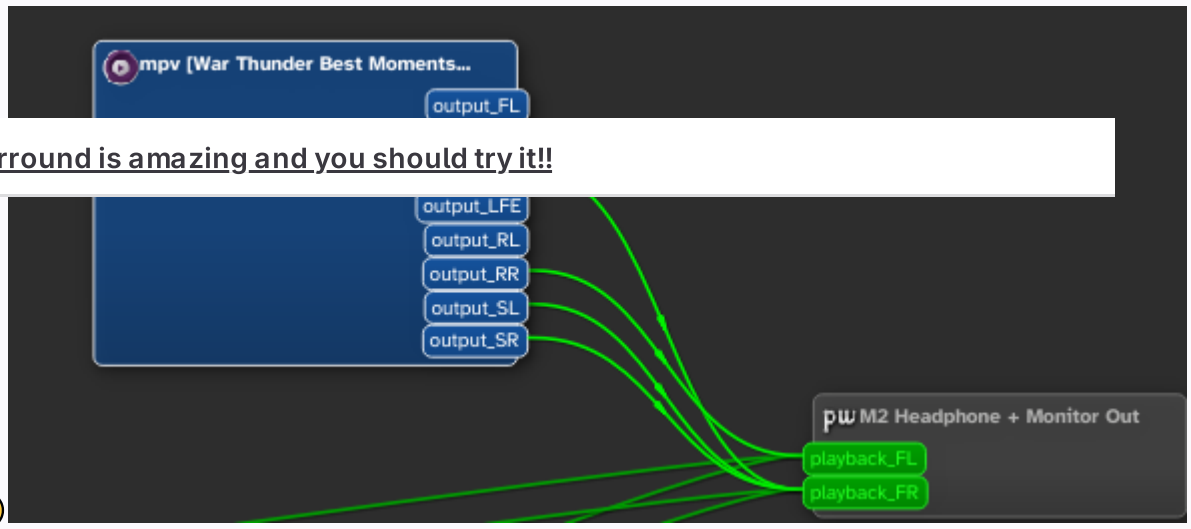
No sound 😔



pallaswept · 10 months ago

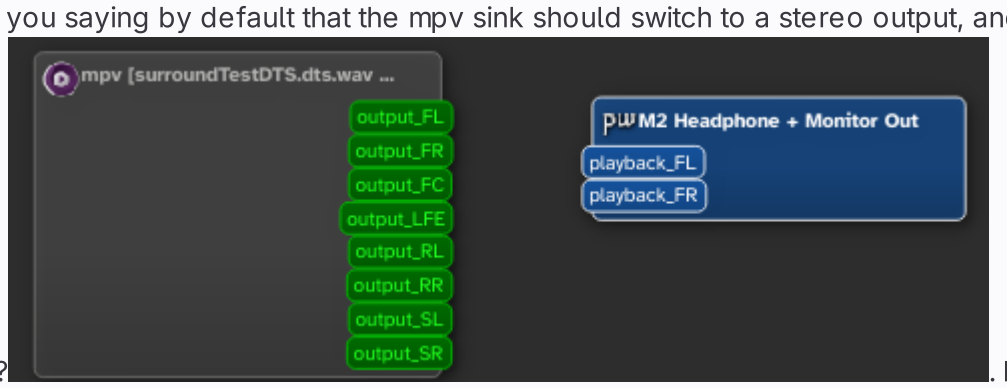
Author

By default, with mpv totally disconnected from the surround sink like that, it should have changed to a stereo stream to match the Headphone + Monitor sink. You must have some other configuration hiding somewhere I'm afraid.

To help you with testing once you figure it out, you could use this https://archive.org/details/5.1SurroundSoundTestFilesVariousFormatsAACAC3MP4DTSWAV/5.1+Surround+Sound+AAC+Test.mp4

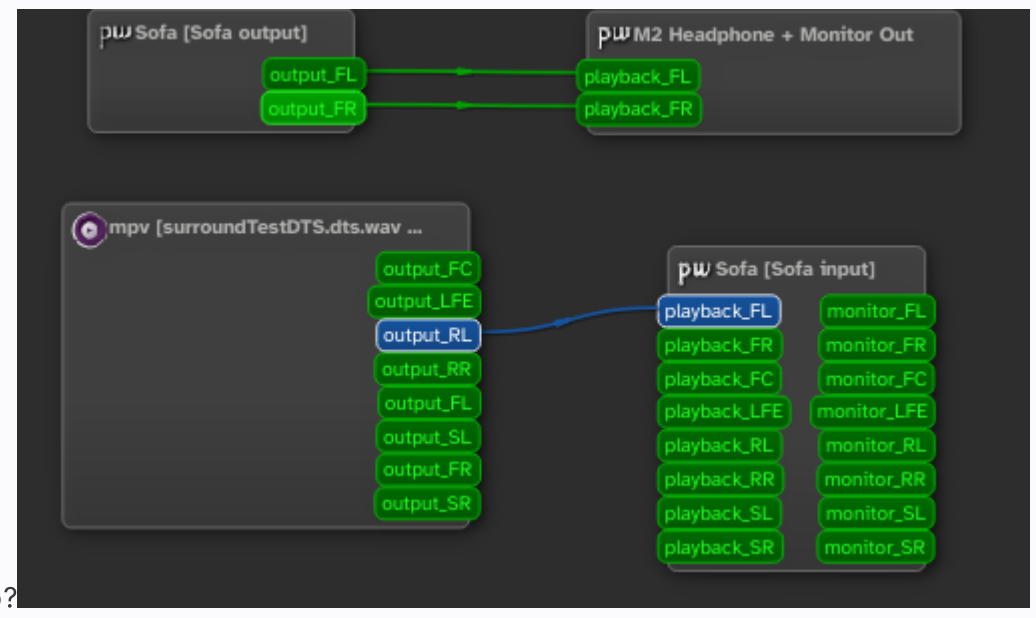
It doesn't have enough channels, but at least I *know* it has some surround channels (it isn't just a random file off the internet which might be in stereo or worse)

JustCauseWhyNot · 10 months ago

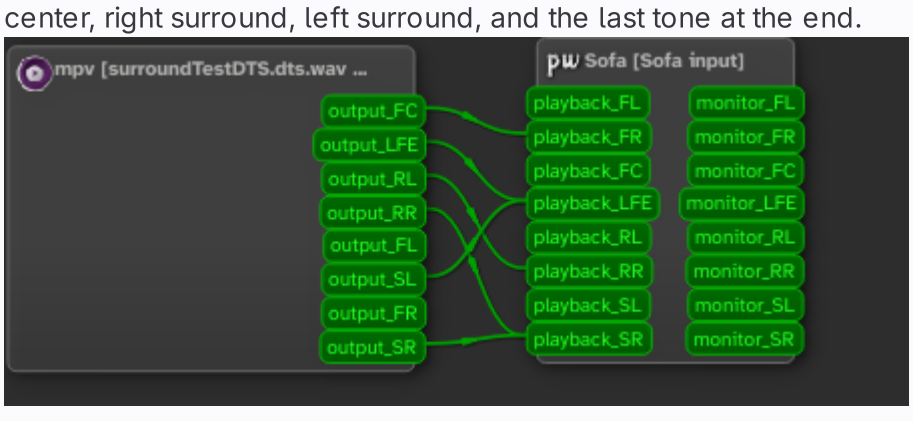
Are you saying by default that the mpv sink should switch to a stereo output, and connect directly to m2 headphone + monitor out? 

. It was set that way in ncpamixer. I had the output set to sofa, and not m2. Once I switched it to m2 mpv switched to stereo.

JustCauseWhyNot · 10 months ago

Is this supposed to give me audio? 

I do hear center, right surround, left surround, and the last tone at the end.



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