VRX EUROPE 2017
Conference & Expo

The Importance of Lighting in Creating Immersive VR

With Contributions from:

storystudio

ARM Enlighten
Real-time global illumination

nDreams

The Importance of Lighting in Creating Immersive VR

Since the dawn of 3D graphics – and even as far back as text-based adventure games – immersion has been at the forefront of game development. How can we create more immersive entertainment experiences? Ones that will grab the attention of consumers to keep them coming back for more.

2016 saw a major step forward in this regard, with the arrival of genuine virtual reality. Aborted attempts have been made several times before, but with technology finally able to provide a comfortable VR headset, performing at a framerate and with graphical fidelity that won't cause instant nausea for the user, VR is truly here to stay.

However this is not the end of the VR journey. In fact, we're really just getting started. With the hardware demands of virtual reality at a premium, and a history in game development of cutting corners by only rendering what the user will see in order to maximise performance – a whole new set of challenges have arrived. Developers can't hide anymore, not when the user has the ability to explore entire scenes in VR and look under every table.

Lighting has long been the linchpin of immersion. Whilst effective lighting can draw a user in to a scene or game, poor lighting is all too often the first thing that causes the entire thing to fall apart.

Within this difficult development context, VR Intelligence sought out three of the shining lights working at the cutting edge of VR development. Representing Oculus Story Studio, ARM and game studio nDreams, these industry thought leaders deliver key insights that cut through the mysticism of effective lighting in VR in this free white paper.

And for even more insights, plus the opportunity to network with the biggest players working in virtual reality today, don't miss your chance to attend the next instalment of the world leading VRX event series, VRX Europe in London on May 11-12 2017. See full details here:

www.vr-intelligence.com/europe

Interviews conducted and compiled by Thomas Wallis

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storystudio

Max Planck is the Technical Founder of Oculus Story Studio. He has been working to design and build the technology and teams that tell stories in innovative new ways.

In your opinion, what are the main challenges with lighting in VR?
We use the Unreal Engine for making all of our immersive experiences. The very nature of VR is such that you're getting a lot of feedback from the head mounted display (HMD). You're trying to handle that signal, then show something to the user, and you're aiming for the time gap between those two activities to be less than 11 milliseconds. At the same time you're aiming to achieve a framerate of 90 frames per second, at a 2K resolution.

Every element you add to your content adds time, and each millisecond you add to the render time has to be considered carefully.

Because of all of this, those used to more traditional content creation like computer animation have to go back to the drawing board and consider every element – even down to the detail of what elements should and shouldn't have shadows.

When you're rendering a game that runs at 30 frames per second, as traditional games outside of VR do, you have as much as 33 milliseconds to deliver images back to the player without hugely diminishing the experience. When you have 33 milliseconds to play with, you can add complicated lighting techniques like dynamic shadows and one bounce global illumination.

When you only have 11 milliseconds you have to make some really hard choices. The trade-off is between the number of triangles you put on the screen and the lighting model you employ. It's a trade off with everything we do.

With Henry we decided to embrace an animated style. As such shadows were just approximations, rather than something more photo realistic which would have meant doing a shadow map pass.

In Dear Angelica we actually don't really have a lighting model. Instead we just have these beautiful ribbons of illustrated curves drawn around you. Because the lighting model was so simple, we could put a lot more triangles up on screen.

I have a background of computer animation, and amongst the first things you learn when lighting in computer graphics are how to place a key light, a bounce light, and a rim light. Bounce is used to add more

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appeal and glow to the face, and rim is used to create separation from the background. What we're finding in VR is that rim is not needed as much because the user gets so many visual depth cues from moving their head around with their stereo vision.

What impact do the frame rate constraints have on VR experiences – and how can effective lighting help with this?

I think the differences between Henry and Dear Angelica kind of demonstrate that trade off pretty well. In Dear Angelica, at any given time you have about five million triangles in an illustrated style.

Because of the more sophisticated lighting model in Henry, we could only afford to put up maybe one or two million triangles. That's how carefully you have to weigh up the importance of lighting for whatever you are creating in VR.

You have to think about how much geometry you're putting on screen. Lighting is a helpful way to constrain where you need all of that geometry.

In Lost we decided to set the experience within a moonlit forest so that we could hide low resolution areas that were a little further out from where the action takes place. Because it was so dark in those regions, you didn't notice the low resolution, and we freed up resources to render more important detail. The user was tricked in a way – believing that because there was so much detail close up, that detail continued off into the distance.

Having lighting that has the room glow, and where everything is well lit is so much harder to do because you have much larger constraints on your geometry.

Unreal Engine is great because it allows the ability to have skin models and cheap subsurface skin models, and some anisotropic specular and screen-based reflections in a fairly resource efficient way – but each time you add one of those on top, it adds more expense. Outside of VR, in Unreal Engine you can probably pick five different lighting models without too much overhead. Because of VR and the 11 millisecond limit, you can only really pick one or two.

Is dynamic lighting important in scene creation in VR?

A lot of the lighting we do is static. But that does mean you're able to get some good illumination – you can still have a key light and then you allow it to bounce around. To save resource you'll often do a lot of pre-computation and store that within light maps.

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When you want to have a dynamic response, you have to be very careful. In Henry we only had one or two dynamic lights at any given time. We had to be careful to enable and disable them throughout the course of the film.

What's cool about all of this is that it feels like the kind of problems early visual effects had initially. You feel like a pioneer! At that time you couldn't fit a lot into the two gigabyte limit. If you added too much then you would run out memory, time or even break the renderer. Right now real time engines can take a lot, but as soon as you add like three or four dynamic lights then you start getting framerates that are above the 11 millisecond limit.

A lot of VR content development is the art of practicing constraint when talking about lighting.

How can lighting be used to evoke a sense of presence or immersion?

When I was talking about Lost, I mentioned we had these spotlight moments – where we lit up the area around you and lit up a clearing in the forest. It was pretty clear what the stage was and where the action was happening.

In that way I guess lighting in VR is very similar to how theatrical lighting works. The audience member feels like they are in that space. You use lighting to create the area within which you want the user to be paying attention.

There's a moment in Henry where he makes his birthday wish. The lights dim, the sunlight spill is diminished, and there's this magical bit of light that swirls around the balloons that come to life. By bringing down the lights and concentrating brightness into these magical stars, everyone follows that and understands what is going on.

In visual effects you tend to use light to make a particular framing work well. In computer animation a lot of times the framing was decided before lighting got in there. It is then a case of lighting being added on top of the composition to try and convey the intent of the director.

With VR, lighting is earlier in the process. It is through lighting that you define the area of interest. Working in Unreal Engine, we throw in lights as soon as we start creating our virtual world. In computer animation, the point where you start throwing in lights is the point at which the render starts to get expensive.

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What are the best examples of lighting you've seen in VR content - either for games or film?

There are a lot of great games out there outside of VR that are doing great things with lighting, but they have 16 milliseconds or more to work with.

I was really impressed with what Penrose has done with Alumette. They're doing some really cool tricks in their cloud shading – this really simple voxel marching to get this sense of a glowing cloud.

The stuff that I'm being wowed by are the experiences that are going back to a forward renderer and using a lot of multi-sampling anti-aliasing. Right now in games everyone is using a deferred renderer with temporal AA, which has nice benefits because it softens specular response across many frames. However, in VR you're moving around a lot, and because of that I think the smearing can be distracting.

What you really want to do is to have a simple enough scene so that you can over render, then super sample each pixel. The benefit of MSAA is that you can get really nice transparency. Because you're able to get so much parallax and so many depth cues, it's really cool to see clouds in front of a character and you can see a little bit of occlusion. The best way to do that now is with a forward renderer.

One piece I just played recently that does a great job because it picks one visual style and really sticks to it is Thumper on PlayStation VR. It almost looks like a demo scene experience, but it uses hyper saturated colours really well.

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What are the biggest blockers to rolling out VR to end users? How and when do you think we're going to see mass consumer penetration of high-end VR experiences?

The story of how I got into VR is that I saw the first developer kit from the Oculus Rift – DK1. To be honest I wasn't convinced at that point. The headset did have a pretty good resolution and the optics were pretty good, it also had a decent enough framerate – this was back when it managed 60 frames per second – but it wasn't quite there yet.

It wasn't until the DK2 came out that I was able to look and move around, and then I really felt this sense of presence. But I knew even with the DK2 that it wasn't quite good enough for mass adoption. At that point VR was still only really for early adopters. Those are the ones who were going to be excited about this and see the potential.

Even now with the Oculus Rift on the market, you're aware that you're wearing this thing on your face, you are tethered to a PC and the resolution still needs to get better.

VR today is great for early adopters. The technology we have today will give us enough room to figure out how to make great content. And what's exciting is there is going to be enough of an audience that we will get feedback on what's working.

We are still in that window of early adoption, and we're figuring out how to solve so many VR problems. The time between the Oculus DK1 and the DK2 was less than a year, but the leap forward in technology was one of the major contributors to convincing me that VR is the future.

I believe that the development of technology will continue at this accelerated rate, and that is going to have a big impact on the adoption curve as we move forward.

Do you think VR is a transitionary platform which will ultimately pave the way to widespread AR/MR... or will VR stay as its own platform?

I like AR a lot, but I do see it as a different medium. I can envision a device that gives a VR and an AR experience, but I think of them generally as two separate things.

As a content creator, in VR I can fabricate the entire world around the user, which gives me a much larger canvas to work with. You're able to convince the user that I can teleport them to a different place. By contrast in AR, it's very hard to tell a story to someone in their living

room and make sure that the story works for every possible living room setup.

In AR I'm not going to be able to transport you to Mars and tell you a story there, but in VR I can do that.

The main experience is always reality, so whether you have HUD displays or more information, the type of games I want to play in AR are collaborative games. I want to see what the board game of the future looks like with AR. I'm most excited about castAR, where you can play Dungeons & Dragons and see holograms of your characters interacting with each other.

Whilst I think both will remain as two separate mediums, both will benefit from one another because they are using similar technology. But from a content creation standpoint I think the language of each will be distinct.

What do you see the primary applications of VR to be over the next 5 years?

I'm excited about games, as a gamer myself. I'm biased, but I think VR will be a great place for people to experience story. Story in virtual reality is different – it isn't something that will replace film. I think the major competitor for VR will be TV time because it's an activity you do in the comfort of your own home.

I really want to see VR experiences that are collaborative and social. Even in the simple multiplayer experiences currently available in VR – where you see a representation of where your fellow user's head is and where their hands are – you get so much body language out of just knowing those two things. I can tell who is on the other side before I hear them speak. I can interpolate their gestures and know what kind of body language is coming out of that.

I think people are going to get into VR with their friends and I hope that people are going to use VR to have adventures together; role play together and experience stories from within them. When we figure out that people can come together and experience a murder mystery or a space operetta or an adventure where they have to work together to advance a story – the line between what is a story and what is a game will begin to blur. I think VR is very much an interactive experience. That's why games will make up the bulk of the first wave of content.

VR is inherently interactive, and super simple to grasp. When you think about a game controller, it's actually a pretty complicated interface. A lot of people don't play games because they haven't grown up with

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them. A modern console controller has so many buttons, but that has developed over decades – the first controllers, like the original Nintendo consoles had just a few buttons.

With VR, people know what they need to do within a few seconds because it is really intuitive. I can see that leading to more people trying games without needing to learn how to use complicated controllers.

Which areas do you see the main uptake in photorealistic graphics to be in?

Because the technology is so limited by the 11 millisecond render deadline, I think it's better to stay away from photo real and recognise that constraint.

Pixar chose Toy Story as their first film because they knew how to render plastic really well. The humans were very much tertiary characters in that film. We have to be similarly smart by recognising our technical constraints. Going towards photo real too early is hard. It's difficult to hit photo real even when you have a 30 millisecond render window. In VR I think the uncanny valley is that much larger.

What I am excited about for photo real is the projects that are doing light field capture and simple low resolution capture turned into points.

What I mean by this is a technique where you do a Kinect recording where you get a little bit of depth and low resolution colour and you just project that data as points in space. It looks like a low resolution hologram, however every point you're seeing is being driven by actual data from reality and so you don't feel the uncanny valley, it feels more like videogrammetry. I think videogrammetry and light field capture will be the first ones to achieve photo realism in VR.

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ARM Enlighten
Real-time global illumination

Chris Porthouse is the General Manager of Enlighten at ARM. Enlighten is a middleware product that computes global illumination in real-time allowing for high quality dynamic lighting and rapid in-editor development.

In your opinion, what are the main challenges with lighting in VR?
With virtual reality the big requirement is that sense of presence, that ability for the graphics to make the user truly believe they're in an environment that doesn't actually exist. Lighting plays a huge part in making that happen. If you don't have good lighting you are compromising the entire experience.

A good example is a human's reliance on lighting information for depth cues. Getting the lighting variation correct between distant and near objects makes a massive difference to how believable the world you are in actually is, as does the graduation of light on the surface of larger objects. From a lifetime of practice, humans have an innate understanding of how this area of lighting physics works and if the virtual world breaks our expectations then the sense of immersion and presence will suffer. Even minor artefacts will make the entire scene seem odd and out of place, detracting from the intended immersion.

The challenge in achieving dynamic lighting effects in virtual reality is performance. Baked solutions are an easy fall-back option – yet with offline solutions studios compromise the interactive element of production and gameplay that make VR experiences really stand out.

What impact do the frame rate constraints have on VR experiences – and how can effective lighting help with this?
VR offers so much opportunity to challenge conventional gameplay and graphics; it is a new and exciting platform and developers need to be enabled to innovate in as unconstrained a way as possible despite the obvious performance limits of the platform. While real-time lighting has typically been seen as too computationally expensive when designing a game, it doesn't have to be. It is possible to deploy dynamic light effects without impacting frame rate – and virtual reality experiences will be all the richer if developers design with this in mind.

Meanwhile, if you take a less complex scene but you illuminate it carefully, with well-placed light sources of considerate colours and intensities, it can be extremely impactful. This is especially important to bear in mind for virtual reality where huge polycounts and complex textures may be too expensive to handle.

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Is dynamic lighting important in scene creation in VR?

I think dynamic lighting is essential to VR. It facilitates a more accurate representation of the real-world where interaction with the lighting environment happens whenever you pick up an object, turn on a light or move from one place to another.

I am seeing this thirst for more high quality interaction across the games industry and in numerous other markets, including architectural visualization, manufacturing and film. We're seeing dynamic lighting being employed wherever visual fidelity and interaction is important.

How can lighting be used to evoke a sense of presence or immersion?

In real life if you're walking down a street at night, you feel safe because the street lights are there (although in the slightly darker areas you may feel a little anxious about being mugged). If you turn the lights off and walk simply by the light of the moon and stars, your mind can jump to more ominous or supernatural threats. You walk that same stretch of road in the clean light of day, all that emotion is gone, replaced by security. You can utilise this natural reaction within any gaming experience.

You can also subtly alter lighting to lead the player through a scene in a similar way to how you use audio to grab attention. In a 2D experience you can walk a player through to whatever you want them to see. In VR the player might be admiring, say, an expertly designed chaffinch resting on a tree, when you actually want them to be looking at the boss approaching from behind. Dynamic lighting can be used to guide the player without detracting from the overall experience.

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What are the best examples of lighting you've seen in VR content - either for games or film?

There are a couple of things I have seen that I've found really compelling. I was fortunate enough to visit 20th Century Fox a few months ago and I had a go with The Martian VR Experience. It is just stunning. There's a part of that where you're floating outside the space craft and the sun comes up over the horizon of Mars. The sense of scale within that scene is mind blowing.

There is another one that I found interesting in a completely different way. ARM is building a massive new state-of-the-art complex in Cambridge, UK. We're working with a firm called Cityscape Digital to create a VR experience for our employees so that they can see what the building will actually look like at any time of day before a single brick has been laid. This has been an incredibly rewarding project.

What are the biggest blockers to rolling out VR to end users? And how and when do you think we're going to see mass consumer penetration of high-end VR experiences?

To achieve mass consumer penetration, VR has to scale up beyond console and beyond PC. VR has to be a mobile experience. Which means these devices have to be capable of providing compelling VR experiences efficiently.

ARM is at the centre of designing the CPUs, GPUs, system IP and more for these future platforms. Its latest releases have been targeted at enabling virtual reality on mobile and we expect to see even more engaging VR experiences available on mainstream mobile devices.

Do you think VR is a transitionary platform which will ultimately pave the way to widespread AR/MR... or will VR stay as its own platform?

I think both. Both VR and AR have a place. A VR experience will take you to a completely different world and put you in a completely different space. It will be fantastic for entertainment media, such as films and games, but isolating and better for shorter stretches of time. With augmented reality you're in your current world and bringing things into that world. It has the potential to be used far more widely and for longer periods – if not all the time!

What do you see the primary applications of VR to be over the next 5 years?

Obviously games are going to drive the immediate future of virtual reality. I also see a lot of use cases within the architectural space, whether for real estate sales or enabling better conversations and decision making in major construction projects.

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ARM is also seeing a lot of interest around e-commerce. E-commerce is a one trillion dollar market today, and it grew by 20% in 2016 year-on-year[1]. With that much growth, you have a lot of businesses investing in new technology to differentiate their solutions. Companies like IKEA are testing the waters and seeing what the consumer reaction is to an in-store experience in VR.

Which areas do you see the main uptake in photorealistic graphics to be in?

In e-commerce, automotive and architecture there is an absolute need for photorealism. The art director in the game space has far more flexibility with regards to style than the product designer for a major manufacturer!

How do you see lighting fitting into these pipelines?

Lighting is the biggest contributor to cinematic quality graphics. If you want visual realism and you're in those markets that I spoke about, the lighting has to look correct. Coupled with the fact that high quality visuals are often a route to differentiation further stresses the importance of lighting.

Yet time and workflow are the biggest challenges for studios targeting good lighting. To achieve photorealism artists need to iterate quickly, something which traditional offline solutions can't do. This is where Enlighten can step in. By removing the time spent baking, art teams can iterate faster and achieve the desired look far more quickly. Equally, studios can iterate hand in hand with the client and make better and quicker decisions into the project direction.

1 https://www.emarketer.com/Article/Worldwide-Retail-Ecommerce-Sales-Will-Reach-1915-Trillion-This-Year/1014369

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Jamie Holding and Steven Cannavan are both Senior Programmers at nDreams, a developer and publisher of VR games and experiences.

In your opinion, what are the main challenges with lighting in VR?

Steven: We're used to having digital shadows in 2D games and having everything look very pretty. That's all very expensive in terms of resources. You've also only got a short amount of time to display everything necessary at any given moment.

Jamie: Users are used to having full 1080p, crisp videogames in today's market. The jump from 1080p into even the mid-level VR headset has around three times the performance requirements. Sadly the first things to go are the more sophisticated lighting and shadow models. Any kind of tricks you can come up with to get better lighting and shadows to work in VR are highly sought after.

What impact do the frame rate constraints have on VR experiences – and how can effective lighting help with this?

Jamie: Constantly hitting our target framerate is super important, so there is a huge need for consistent lighting techniques that can remain within our render time budget. Usually games want 30 or even 60 frames per second to run smoothly. In order to get a headset working in such a way that people aren't throwing up, you have to hit 90 frames per second.

Steven: Lighting is also very important when it comes to adding realism to the scene. The simple action of picking something up and seeing a drop shadow so that you can gauge depth is incredibly important. That usually means we have to fake it with dark blobs – we trick you into thinking you're seeing a real shadow when what you're actually seeing is a much more crude representation.

Is dynamic lighting important in scene creation in VR?

Steven: One of the things you want to do in VR is to immerse the user into the world. The last time I checked, the real world was lit with effectively real time lighting! Dynamic lighting is incredibly important, however for the most part you have to cheat, otherwise it simply isn't achievable within VR.

Jamie: With dynamic lighting you need the environment to react properly. If you're in an outside space and you hear bird noise, when you look up you expect to see birds. If you hear atmospheric noise from wildlife or whatever, if you can't see what caused it, it can break that immersion very quickly. In the same way, when introducing a

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spotlight into a scene – if you look up and can't see a light source, you will be immediately brought out of the action.

All objects in the world affect light in some way. They cause shadows; they cause light to bounce around the room in a certain way; they can be affected by other things. If you haven't got effective lighting then it can completely destroy any immersion in VR.

How can lighting be used to evoke a sense of presence or immersion?

Steven: Without dynamic lighting you'd have to be very clever. One of the reasons people have motion sickness in VR is when things don't match up with the model in their head of how the world is supposed to be. Even with a bad VR experience, you can train yourself to be ok with it but then as soon as you take the headset off you'll begin to feel sick again as the world doesn't match up with your model anymore.

When you are missing some of the tools that could help cement your VR world, you have to be clever to try and make things still seem realistic. You have to lock down a scene so that the number of moveable objects is limited for example.

Jamie: Also it can be very game specific – especially if you opt for a style that's abstract. With our work on The Assembly, the game was very early in the VR landscape and we initially didn't have motion controls. Within that environment we didn't have objects that could be picked up and thrown around, so we didn't need too much dynamic lighting.

As soon as you start moving around more, suddenly you want all of the shadows to update along with your movements. It depends very much on the kind of gameplay you're going for.

Steven: You've also got the problem of user freedom – users can shove their heads into cupboards or bend down and look at the underside of a desk, so you have to light everywhere. Before, you wouldn't bother generating anything underneath a desk, if you were to look there would just be nothing there. You just can't do that in VR.

For so long in the games industry we have spent the bulk of our time cheating. Now we're at a point where we're going to have to start rendering everything again.

Jamie: There's a whole bunch of examples where we use 2D planes to create 3D objects in games. In VR, because of your depth perception,

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now you can see that as a flat image and it completely destroys all the old tricks we used to do.

What are the best examples of lighting you've seen in VR content - either for games or film?

Jamie: I think we did some pretty good lighting in certain parts of The Assembly – particularly within our flashback sequences. These were very abstract sections where you were in a noise-filled courtroom that had no people in, and different areas became spot lit and drew the player along the route we wanted them to go.

I also really liked PlayStation VR Worlds. That was a launch title for PlayStation VR. The London Heist has this great bit where you're in a dark room and can see things moving around, then a light comes on and a guy is interrogating you whilst you sit in a chair. It's really effective.

Steven: Within PlayStation VR Worlds again, their use of lighting during Ocean Descent was excellent. So I think we're agreed that Sony have done a pretty good job so far!

What are the biggest blockers to rolling out VR to end users? And how and when do you think we're going to see mass consumer penetration of high-end VR experiences?

Steven: From my point of view it is price. To get a decent VR experience you need a pretty hefty, graphically capable computer. Down the line these may become more affordable, and therefore VR will become more affordable. The mobile space is where I think VR will be biggest for quite a while.

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I'll be interested to see if anyone makes a dedicated mobile VR headset, because as soon as we have dedicated mobile VR hardware, I can see the whole VR market accelerating.

Jamie: The mobile side will be quite interesting for a while because people happen to have these phones that can power VR experiences, then they take a punt and buy the VR headset that goes with it. You are going to get a lot of users from that, but I'm not sure you're going to capture the hardcore gamer market in quite the way that PC-based VR will.

It'll be interesting to see how it evolves, especially as Google's Daydream extends to more and more devices this year.

Adoption and use will increase exponentially as technology moves forward. We need to get to the point where you know exactly where a device is and its orientation without the hardware overheads that we have today, and we're going to see that with things like Google Tango technology.

Steven: A lot of the pick-up we're going to see in these early days will be from the PlayStation VR. A lot of people already have a PS4 to run it, and then it's just a case of taking it home and with minimal set-up you can start playing. Reducing those barriers between the purchase and actually using the thing will have a dramatic impact on adoption.

Do you think VR is a transitionary platform which will ultimately pave the way to widespread AR/MR, or will VR stay as its own distinct platform?

Steven: I think VR will always be a separate entity to everything else. It's a very different prospect where you're going to be immersing yourself into a world. It's probably going to be used for entertainment and in my mind will probably be used more for education purposes as well. I can see a future not too far off where museums have 360 captures of their pieces so that anyone who can't physically get along to the premises will be able to still pay and experience each of the exhibits.

Augmented Reality on the other hand, I see that working more towards the business end, as well as medical and research applications. I can see that being incredibly useful.

Jamie: AR and VR tackle very different problems, and there is some overlap. There are some games that will work very well in AR. For example the Minecraft demo on Hololens is pretty awesome. I can imagine seeing certain games appearing on my coffee table using AR.

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At the same time, a lot of VR games won't work in AR. I want to be immersed, and you can't get that through an AR headset.

Both of these techs need a lot of image processing and pumping graphics to a very small device on your head. Because of that, both AR and VR are going to evolve alongside each other at a similar rate. As soon as VR has picked up pace and started to get a lot of consumer attention, you're going to get AR picking up alongside it.

Ultimately I think there will be an AR/VR crossover headset maybe five or six years down the line, but in the mean time I can see these both taking similar spaces in the market, targeting different audiences, but still sharing a lot of the same tech.

What do you see the primary applications of VR to be over the next five years?

Steven: Entertainment will take up a lot of the use cases in the next five years. I also think education and training will also see a lot of applications. It's cheaper to put someone into a headset and learn how to pilot an aircraft than putting them in the simulator, it wouldn't replace it but I'd imagine it would be a welcome addition. So, from a cost cutting point of view I can really see VR taking off.

Also I'm aware of companies that are using VR for customer research. IKEA for example have virtual stores and they're tracking how people are picking up and looking at their products to build up market research data that feeds directly into their product development.

Jamie: Video games are going to be the big dominating force for a little while because that seems to be where a lot of the attention is right now. With the introduction of motion controllers we're seeing creativity products like Oculus Medium and Tilt Brush becoming very popular. Artists are creating amazing environments and full character rigging inside of VR. Five years from now the idea of creating 3D content on a 2D screen will seem pretty dumb.

Which areas do you see the main uptake in photorealistic graphics to be in?

Jamie: The main drivers of photorealism in VR is probably the architectural visualisation stuff. With games you need so many things to happen all at once like gameplay logic, lighting, networking – a lot of the headsets don't quite have the throughput to achieve photorealistic graphics just yet.

Whilst we were very close to getting photorealistic graphics in 2D games, in VR we've had to pull back a little bit simply because of

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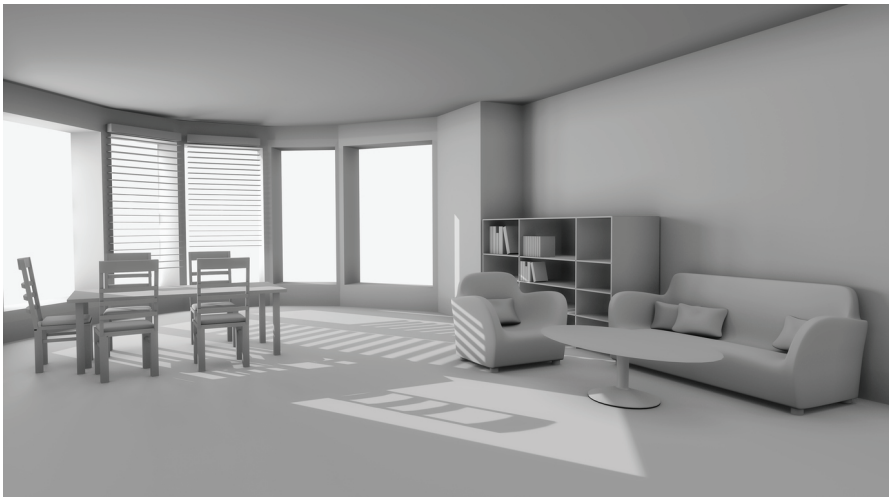
the extra processing power that's needed to create a decent user experience.

With artificial visualisation, often not a lot of stuff is moving. In the Unreal Engine forums I've seen people doing visualisations of apartments or buildings and they look stunning in VR. When you put on a high-end headset it really does look like a photograph. That part of the industry is really going to push initially, then maybe in three or four years we'll start to achieve the levels of realism within VR that we're already achieving in 2D games today.

Steven: Apart from that, I can see people bringing photorealism into entertainment, but having it more fake in that you'd have a VR movie playing ahead of 3D objects, and having those objects dynamically lit in between a movie being played.

Another area that could really drive photorealism within VR forward is if VR causes the resurgence of the arcade – a dedicated space that can afford to lay out a lot of money to provide hardware with significantly more power than the average consumer can afford. Then if users spend two or three quid to experience that, then maybe you might have the resources to provide enough power to reach close to photorealism.



How do you see lighting fitting into these pipelines?

Steven: At the moment, we have game engines that are purpose built for 2D. We have come along and smooshed VR on top. I imagine further down the line we will have more VR specific engines. I'm aware of techniques like Clustered Forward Rendering where people are using the clusters and mega textures to work out what parts of the shadow map actually need to be updated.

The Importance of Lighting in Creating Immersive VR

There are lots of techniques that are being used to reduce latency. Our GPUs today are all focused on throughput that has nothing to do with latency. We've been through a graphics revolution where you can throw everything on the GPU and not worry about it. Now we have to be much more specific and tell the GPU that it has to have certain tasks completed within a short timeframe.

For the first few years at least we're going to be creating VR experiences using hybrid game engines and just muddling through.

I went to a lecture recently where the professor said that in the early '80s you had techniques where you could go in and tweak how things were rendering along the scan line. These kind of techniques were abandoned for efficiency, but we might actually come back to technology that we were looking at in the '70s or '80s because it could be really useful when applied to VR.