Building Eye Tracking on Meta Quest Pro Responsibly

Meta's new virtual reality headset, Meta Quest Pro, introduces inward-facing eye sensors to facilitate better communication and comfort, enhanced expression and deeper immersion. Two features utilize these sensors at the launch of Meta Quest Pro—eye tracking and fit adjustment—but we'll just focus on the eye tracking feature in this paper. Below, we outline how we have developed Meta Quest Pro eye tracking in alignment with our Responsible Innovation Principles.
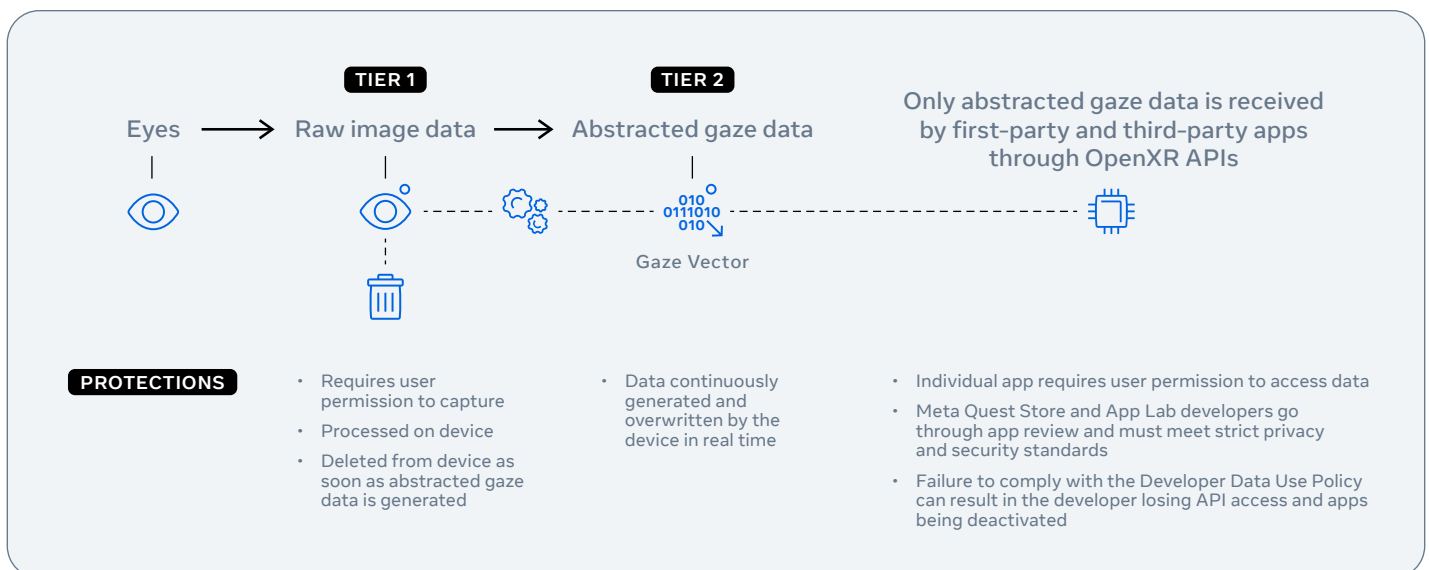
01
What is eye tracking?

As we explain in our Eye Tracking Privacy Notice, this feature on Meta Quest Pro uses inward-facing cameras to estimate the direction of where your eyes are looking. Building on other natural input technologies, like hand tracking, eye tracking is an important technology to enable the immersive, embodied internet that will be a key part of the metaverse. With eye tracking, people can experience new benefits to using VR, including:

- **Improved presence:** Eye tracking improves social presence in VR, which gives people the feeling of "being there together." With eye tracking enabled, a user's avatar can more closely mirror their natural expressions while in VR — like being able to blink or make eye contact with other people.

- **Improved image quality and device performance:** Eye tracked foveated rendering focuses computing power to provide high-quality graphics of where a user's eyes are directed and reduces rendering quality at edges of the visual area outside of the prime focal area.

- **New method to interact with virtual content:** Eye tracking can be used as a new control input, potentially offering new accessibility benefits. Instead of using controllers or other physical inputs, users may be able to navigate and control their experiences in VR using their eyes as an input mechanism.

TIER 1 — Raw image data
TIER 2 — Abstracted gaze data

Eyes → Raw image data → Abstracted gaze data

Gaze Vector

Only abstracted gaze data is received by first-party and third-party apps through OpenXR APIs

PROTECTIONS

- Requires user permission to capture
- Processed on device
- Deleted from device as soon as abstracted gaze data is generated

- Data continuously generated and overwritten by the device in real time

- Individual app requires user permission to access data
- Meta Quest Store and App Lab developers go through app review and must meet strict privacy and security standards
- Failure to comply with the Developer Data Use Policy can result in the developer losing API access and apps being deactivated

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How does eye tracking work?

Off by default on the Meta Quest Pro, eye tracking, if enabled by the user, is performed via inward-facing sensors that capture raw images of a person's eyes, which in turn, are used to generate abstracted gaze data, or gaze vectors. This data is a set of numbered coordinates that represent an estimate of where a user's eyes are looking in VR.

To protect privacy, raw eye images are processed on device and not stored – they are deleted as soon as the abstracted gaze data is created. The abstracted gaze data is what is ultimately shared to apps if they integrate our OpenXR APIs, and is what allows a VR headset to 'place' a user's gaze and customize the VR display. This data sharing requires a user's permission on a per app basis.

The data associated with eye-based technology in VR is not a single catch-all category. We distinguish between different levels of potential privacy impacts by differentiating raw eye image data (tier 1), which is deleted, from the abstracted gaze data (tier 2), which is continuously overwritten (meaning old data is replaced with new as the feature is being used), that is derived

from it and shared through the API.[1] We view these as two separate tiers of eye tracking data that warrant different sets of protections.

To maintain consistency with industry practice, our eye tracking API designs for Meta Quest Pro are anchored on Android NDK from the Android Open Source Project framework that our headset is built upon and the industry-wide OpenXR standard for inputs. We collaborated with industry partners to develop the OpenXR standard for eye tracking APIs to help facilitate an interoperable and consistent approach to eye tracking software development across the VR developer ecosystem.

In the case of VR, abstracted gaze data is needed so that a person's avatar is looking in the correct place. For example, if a VR user is making contact with another person in virtual space, the application needs to know this so it can show that user's avatar making eye contact. This is not only true on Meta Quest Pro but on any VR device that uses the OpenXR standard.

03

How does Meta apply its Responsible Innovation Principles to eye tracking?

Meta's Responsible Innovation Principles guide the responsible development of our technologies, including eye tracking.

The 4 principles, which are explained in more detail in the Responsible Innovation Hub, are:

- Put People First
- Provide Controls that Matter
- Consider Everyone
- Never Surprise People

These principles inform the work of teams across Reality Labs, including engineers, product designers, user experience researchers and privacy experts as we have collaborated to build eye tracking on Meta Quest Pro responsibly. This involved working across disciplines, as well as consulting with external experts, to consider the risks that this technology presents and the appropriate protections to mitigate them.

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1. As with every new product, this technology is evolving, so we will continue to iterate on these tiers. Find more information and additional data types in our Eye Tracking Privacy Notice.

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In the following table, we highlight how our Responsible Innovation Principles apply throughout the user journey of eye tracking:

Consider Everyone

Relevant Time Period: Iterative process that begins in early product development

Application of the Principles in the context of eye tracking	Product & Policy Features
Optimize machine learning models for a diverse set of people.	Eye tracking machine learning models were trained and evaluated across diverse genders, ethnicities, eyewear and makeup usage.
Consult with external experts for their feedback on risks and opportunities.	Privacy advocates provided early input and feedback on eye tracking user controls design and language, draft Privacy Notice language, and other general concerns around the eye tracking feature.

Never Surprise People

Relevant Time Period: Pre-purchase and in-product

Application of the Principles in the context of eye tracking	Product & Policy Features
Provide users the choice of whether or not to use eye tracking, and explain why it can improve a VR experience if enabled.	Eye tracking is off by default. Users are given information about the feature, and the choice whether to enable it, in VR and in a context that makes clear why and how the data will be used.
Educate and inform people about the eye tracking feature and how it works.	An app's Meta Quest Store page will indicate if the app supports the eye tracking feature, so people are aware before they purchase. In-product, users are given the option to enable this feature with information about how it works and a link to learn more. A blog post, which includes video demonstrations, explains and shows the Meta Quest Pro privacy features and controls, and a new Help Center article explains eye tracking specific controls. On our website, the new Eye Tracking Privacy Notice and updated Supplemental MPT Privacy Policy provides more detail about the data collected and how it's used and shared.

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Provide Controls that Matter

Relevant Time Period: In-product

Application of the Principles in the context of eye tracking	Product & Policy Features
Provide both system-level and app-level controls for the eye tracking feature.	Eye tracking is off by default. Users can turn eye tracking on and off in Settings and control which apps can access their eye tracking data on Meta Quest Pro. This means that users can choose to enable eye tracking only for the apps they want to use it on. We're building an indicator in the Quest Pro menu bar that will show users which apps they have allowed to access eye tracking.
Provide controls for users to easily manage their permissions.	Eye tracking can be paused at any time in the "Quick Actions" menu, which allows users to stop all eye-tracking processing without having to go through setup again when they're ready to re-enable it. Users can also choose whether they want to calibrate eye tracking, and choose to delete calibration data from their device at any time.
Make privacy settings easily discoverable throughout the user experience, using consistent language.	In addition to clear and transparent instruction during initial setup, the eye tracking setting is clearly labeled and found under Movement Tracking in Settings. This is the same location where users also find settings for similar features, like hand tracking. The same terminology is used across calibration, requests for permission, notifications, settings, and education on our website (blog post, Privacy Notice).

Put People First

Relevant Time Period: When permission is obtained and the feature is turned on by the user

| Application of the Principles in the context of eye tracking	Product & Policy Features
Process eye tracking data in a privacy-preserving way, such as on-device and with minimal data retention.	The raw images or video data directly captured by inward-facing sensors are processed in real time on the headset and deleted from the headset after the abstracted gaze data is generated. This means that neither Meta or third parties have access to this raw image data. Abstracted gaze data is continuously generated and overwritten in real time as it provides the eye tracking feature.
Prevent developers (both first and third party) from accessing raw images or video from sensors.	
Developers must comply with our data use policies, that outline permitted and prohibited uses, and we take action if a developer does not comply.	Developers must comply with our Developer Data Use Policy (DDUP). The DDUP and developer documentation explicitly reference eye tracking, so developers are aware of permitted and prohibited use cases, as well as obligations to articulate their collection, use, and processing of the data. We perform proactive API monitoring to scan for signals of potential misuse of eye tracking data. Violations of our policies can result in developers losing API access and their apps being removed from the Meta Quest Store.

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Past, Present, and Future Consultation with the Global Research and Policy Community

As we build for the metaverse, we will continue to prioritize user research and apply insights from our engagements with global communities to ensure we build our products responsibly.

For example, as an integral part of our design process for the consent flow for eye tracking in Meta Quest Pro, we consulted privacy advocates to seek feedback on the design and language of the opt-in screen, as well as our plans to provide opt-in privacy controls for these features at both the system and app level. These conversations emphasized the importance of user education, so we developed information about our privacy controls and features, including a blog post focused on the privacy features and controls, and incorporated additional feedback from experts into the language of our Eye Tracking Privacy Notice that we link to in the user opt-in screen.

We also met with accessibility experts about the new eye tracking capabilities to hear about its implications for their community, and received positive feedback—especially about gaze as a new control input. We currently provide it as an API for VR developers and will continue to explore its exciting possibilities.

Looking ahead, as we work with stakeholders across the globe, we intend to continue to support academic research and privacy experts in exploring the open questions, benefits and impacts of eye-based technologies. We'll also continue consulting with external experts as we design privacy controls and analyze the trade-offs inherent throughout the product development process. Finally, we are working with several key partners to develop privacy guidelines and system-by-design approaches for immersive technologies, including organizations like the Metaverse Standards Forum, World Economic Forum and XR Association.
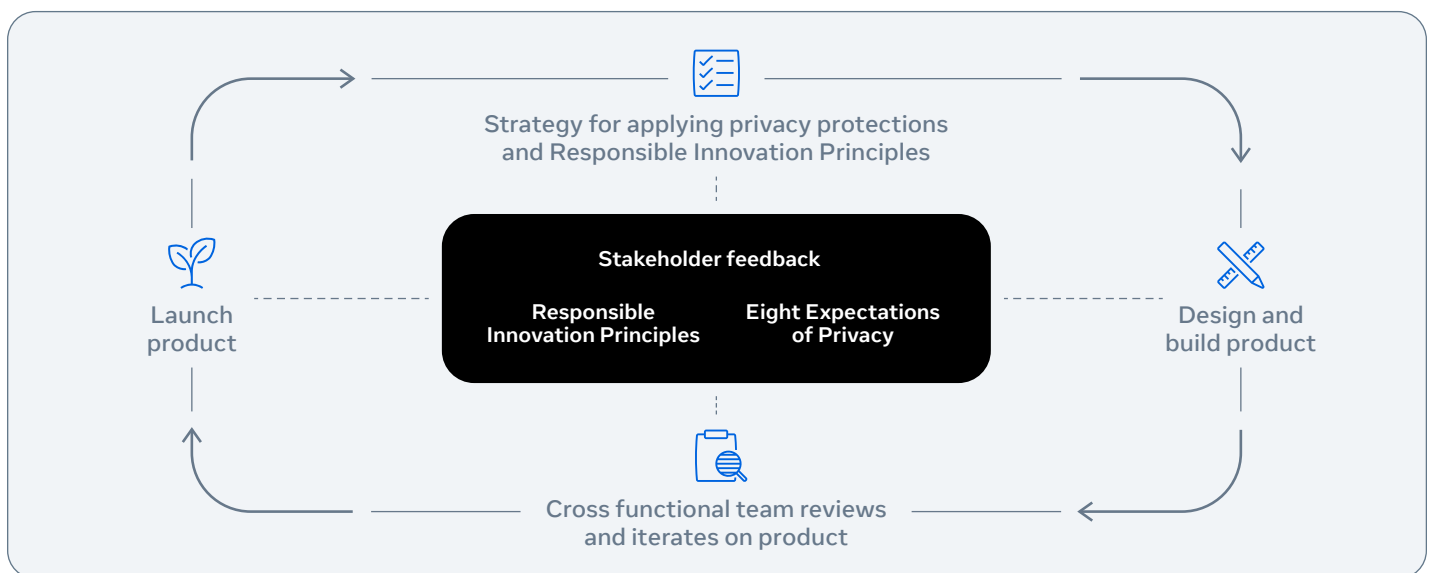
Transparency and partnerships will remain critical to developing this technology responsibly as an industry. At Meta, we will continue to share our ideas on eye tracking, novel applications that rely on this data and what we can do to protect privacy and develop this technology responsibly, with the hopes of continuing to collaborate with key partners to build best practices as this industry grows.

Glossary

Abstracted gaze data	An output derived from raw eye-image data after it has been processed.
Android Open Source Project	Open source operating system for mobile devices and a corresponding open source project led by Google that is used on Meta Quest Pro.
APIs	Application Programming Interfaces (APIs) are computer code that makes it possible for apps or software programs to integrate and communicate with one another. APIs also allow the exchange of information using a set of simple commands.
Calibration	Calibrating eye tracking allows the VR headset to adjust the eye tracking software for a more comfortable, accurate, and higher quality viewing experience. Calibration is optional.
Calibration data	A set of numerical correction factors for each eye that help the headset software more accurately estimate the direction of where a user is looking.
Eight Expectations of Privacy	The development of Meta's products, services or practices is guided by our internal privacy expectations which include purpose limitation, data minimization, data retention, external data misuse, transparency & control, data access and management, fairness, and accountability.
Eye-based technology	Technologies that rely on information about a user's eyes to enable new features or use cases.
Eye tracked foveated rendering	A rendering technique that enables more efficient use of limited graphics processing unit (GPU) resources by lowering the pixel resolution in areas a user is not directly looking.
Eye tracking	Feature on the Meta Quest Pro headset analyzes infrared images of users' eyes to create an estimate of where their eyes are looking in VR.
Fit Adjustment	Feature on the Meta Quest Pro that helps ensure the VR headset is fitted optimally for better comfort, visual clarity, and VR experience. When using the fit adjustment feature, the headset uses its cameras to detect the position of users' eyes and lower face to check whether the headset is aligned optimally and provides headset adjustment tips. It is an eye-based technology but separate and distinct from the eye tracking feature. See more information in the Fit Adjustment Privacy Notice.
Gaze vectors	The direction that people's eyes are looking.
OpenXR	OpenXR is an open standard for accessing capabilities on AR and VR platforms and devices. More information is available from the Khronos Group.
Quick Actions	This panel provides shortcuts to frequently used controls and actions like device volume, mute/unmute microphone, and setting up Guardian. The panel can be accessed from the universal menu anytime, anywhere in VR.
Raw eye-image data	Images or videos of eyes directly captured by the device's sensor, before it is further processed, deleted, or abstracted.
Rendering	The process of creating the 3D images within an application in order to depict a virtual world. The operating system on Meta Quest Pro does not do rendering work for apps; rather, it is done within each application. Whether using Workrooms or any other app that enables the use of eye tracking, the application needs access to abstracted gaze data in order to render a user's eye position within the avatar or to render the display.
Settings	Settings provide controls over key Quest systems and features. It includes a dedicated settings panel to enable or enable the eye tracking feature.

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