

移动平台开发技术

iOS移动平台AR基础

章国锋 2025春夏学期

什么是AR

ARKit

构建AR应用

什么是AR

ARKit

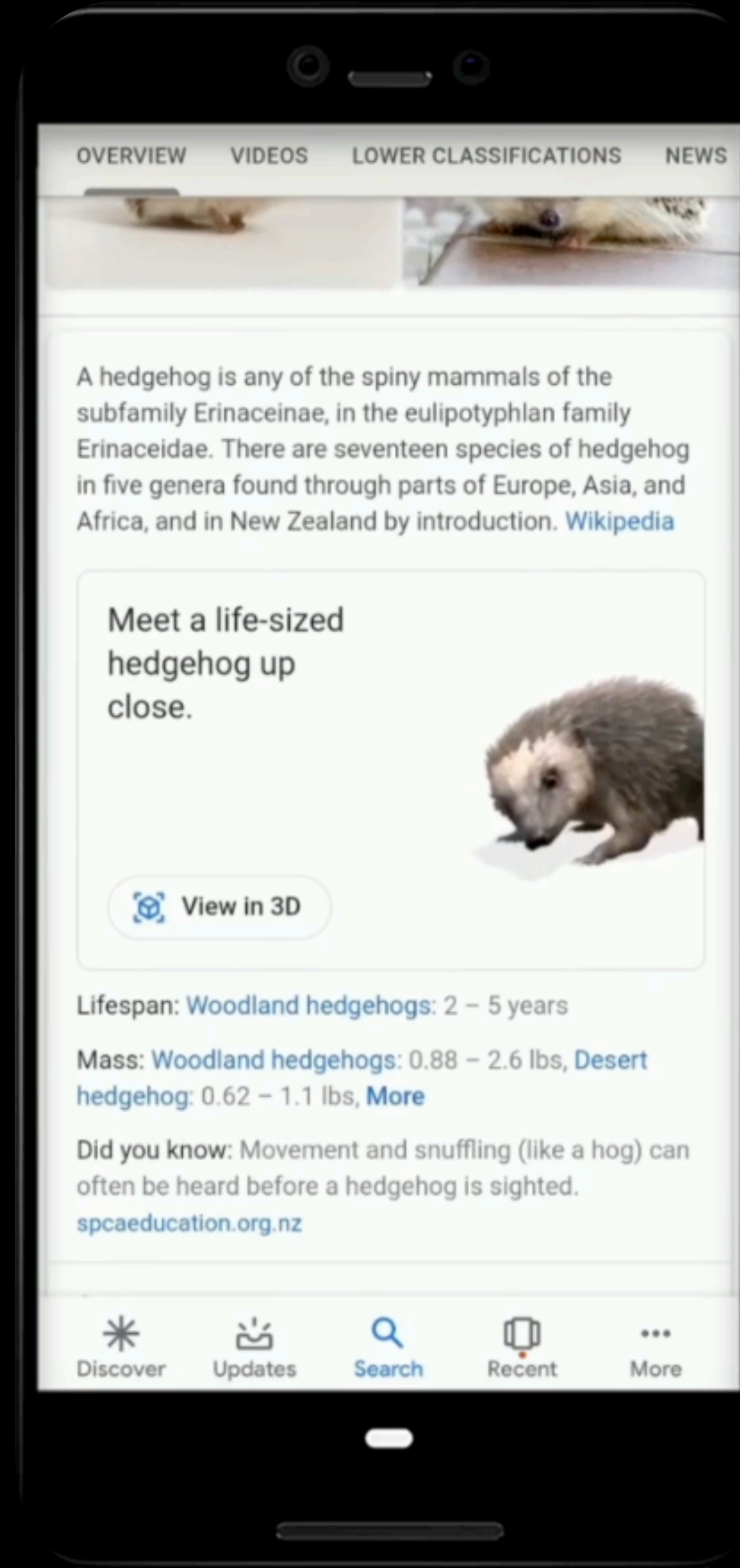
构建AR应用

Augmented Reality



什么是AR

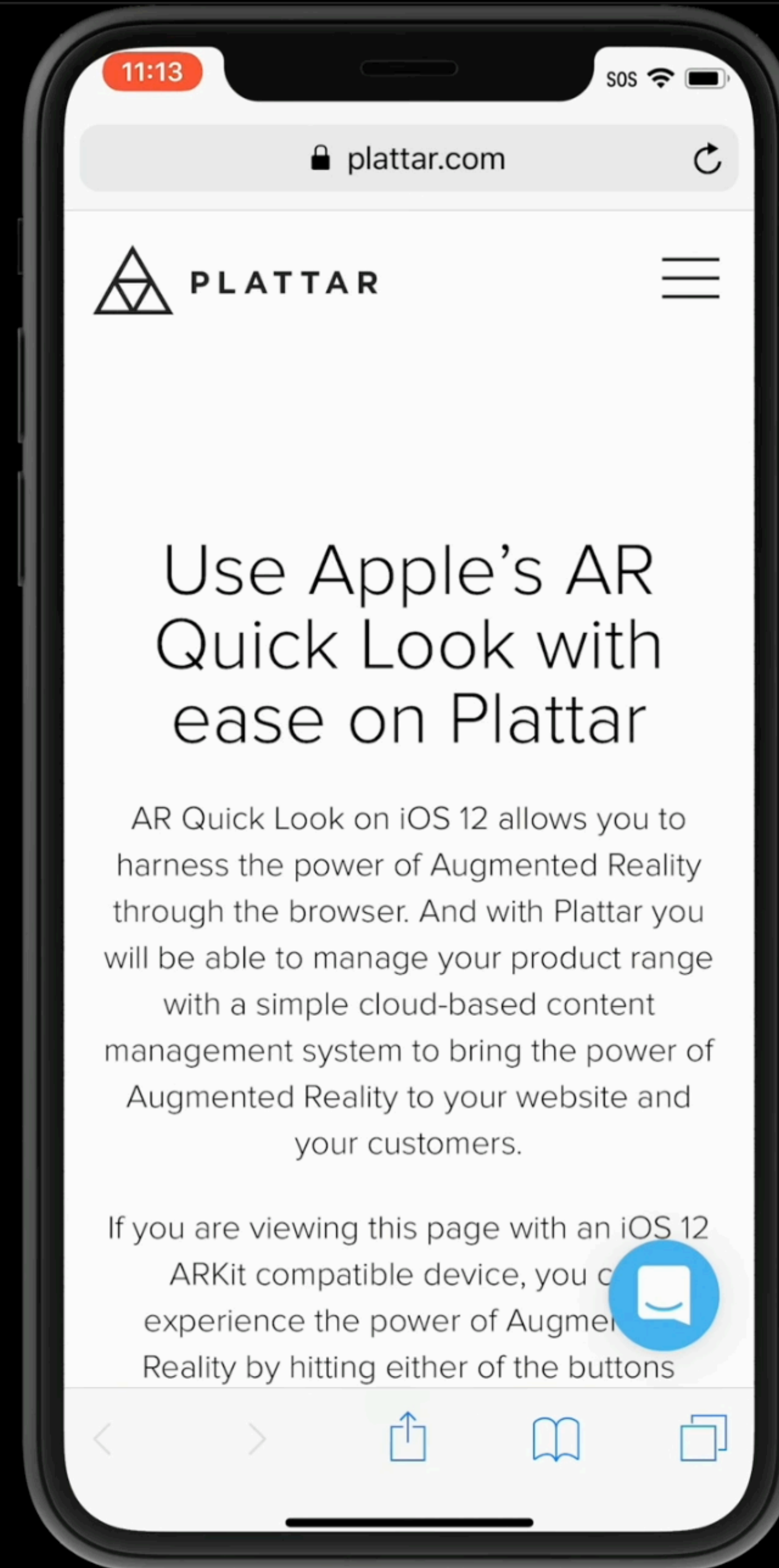
What the heck is AR?



AR in Google Search

什么是AR

What the heck is AR?



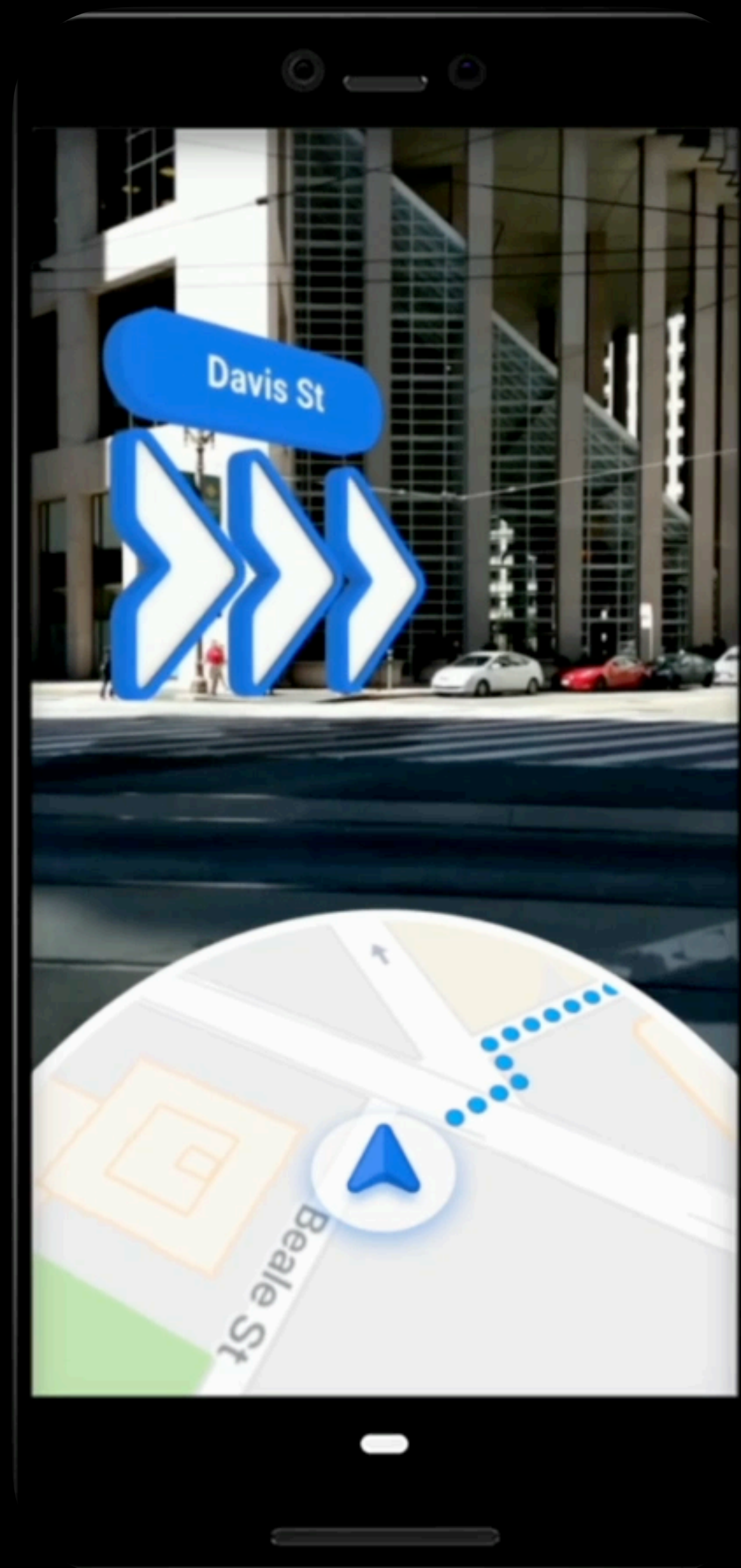
Apple ARKit
AR Quick Look

什么是AR

What the heck is AR?



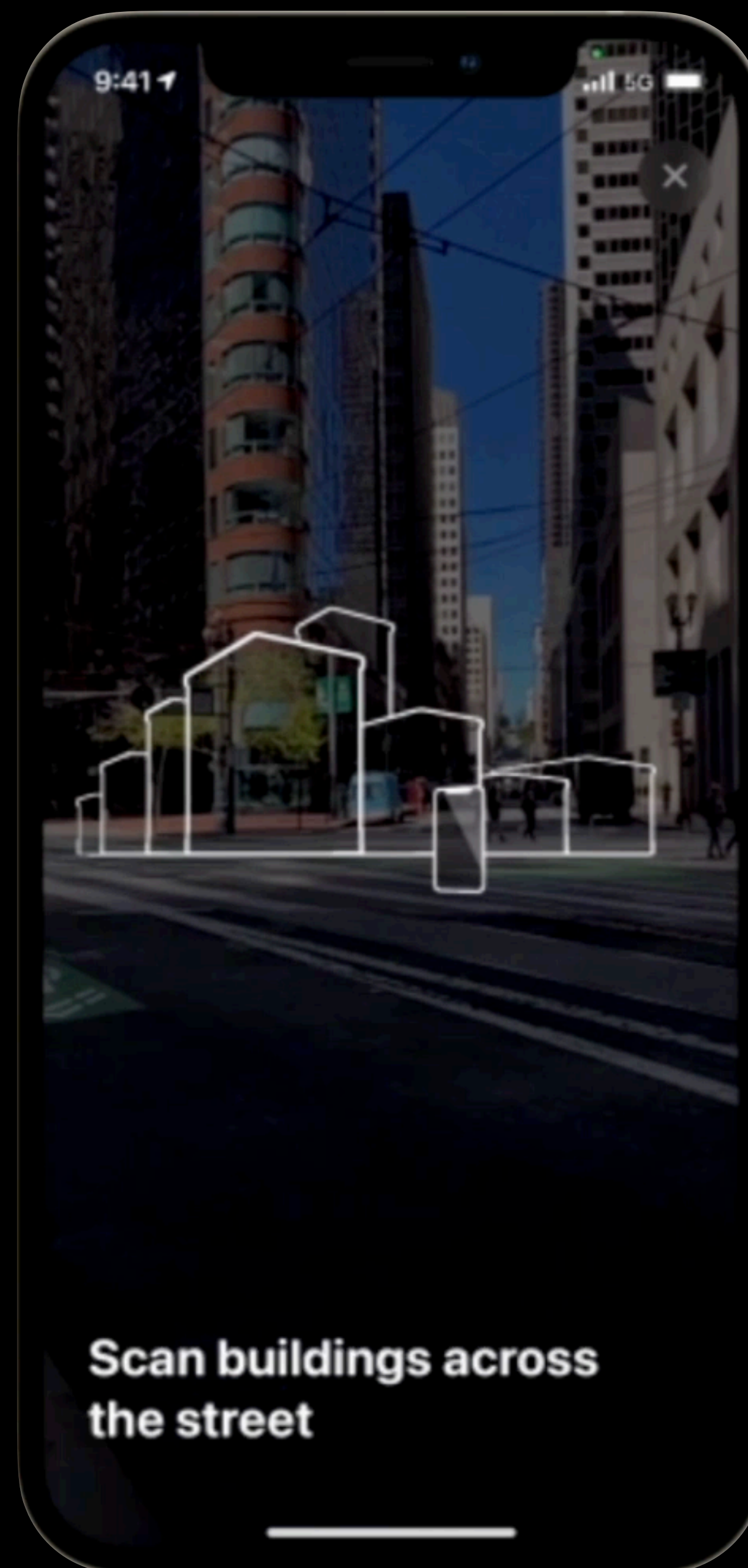
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Google Map
Using AR to guide

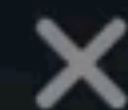
什么是AR

What the heck is AR?



Apple Map
Using AR to guide

手机拍摄



手机连接记录仪 Wi-Fi

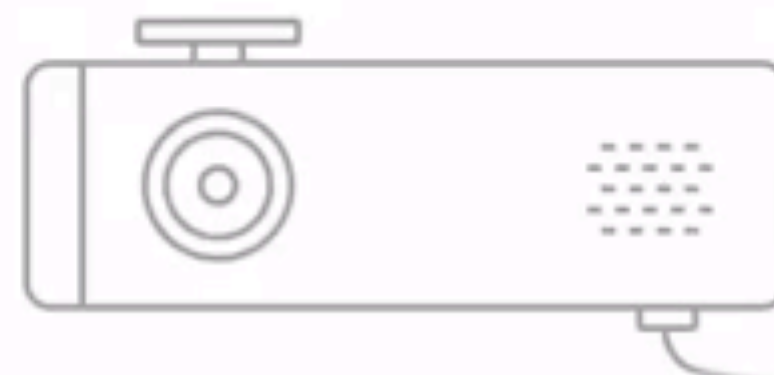
1. 查看行车记录

查看支持设备

2. 打开“设置-无
行车记录仪名称

1234567890

连接 Wi-Fi 后，验证设备



正在连接设备中...

连接 WIFI

网络不佳

什么是AR

What the heck is AR?



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🤔 通过刚才的短片，大家能总结一下AR是什么吗？

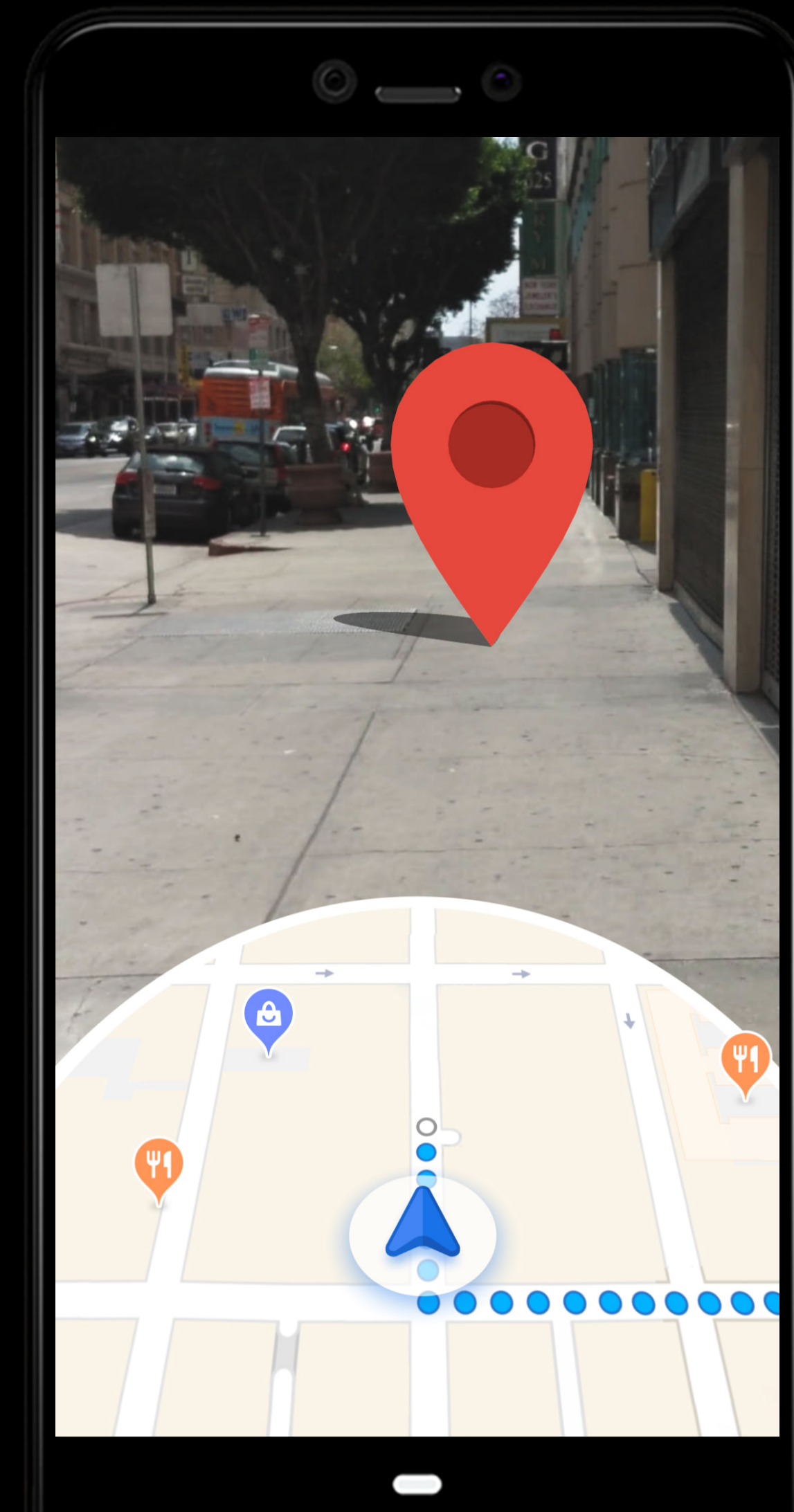
AR是.....

So the AR is?



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- 增强现实 (Augmented Reality)
是将虚拟的信息叠加到现实世界中，实现虚拟场景与现实世界无缝融合的效果。



AR, VR以及MR, XR

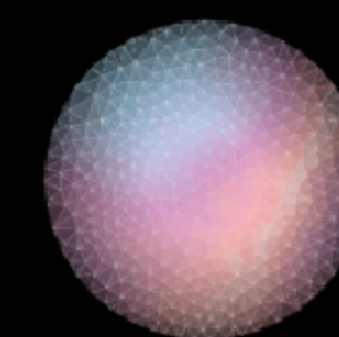
The difference between AR, VR, MR and XR

- **虚拟现实 (Virtual Reality,VR)** 提供用户一个区别于现实世界，完全沉浸式的虚拟世界体验。
- **混合现实(Mixed Reality,MR)**包括增强现实和增强虚拟，可以将虚拟世界和真实世界无缝融合起来。
- **扩展现实(Extended Reality,XR)**泛真实与虚拟组合的、可人机交互的环境，包括AR、VR、MR。

PHYSICAL WORLD



DIGITAL WORLD



AUGMENTED REALITY

VIRTUAL REALITY

MIXED REALITY SPECTRUM

AR背后的技术

What makes AR so powerful
Computer Vision



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Scene Understanding

Surface Estimation

SLAM

Feature Detection

Sensor Fusion

Augmented Reality

Camera Intrinsics

Camera Calibration

Light Estimation

Bundle Adjustment

Visual-inertial Navigation

Feature Matching

Nonlinear Optimization

Optimal Correction

AR背后的技术

What makes AR so powerful
Computer Vision



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SLAM

Augmented Reality

Triangulation

Scene Understanding

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Camera Intrinsics

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Visual-inertial Navigation

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Optimal Correction

什么是AR

ARKit

构建AR应用

什么是AR

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构建AR应用

ARKit

What the heck is ARKit?

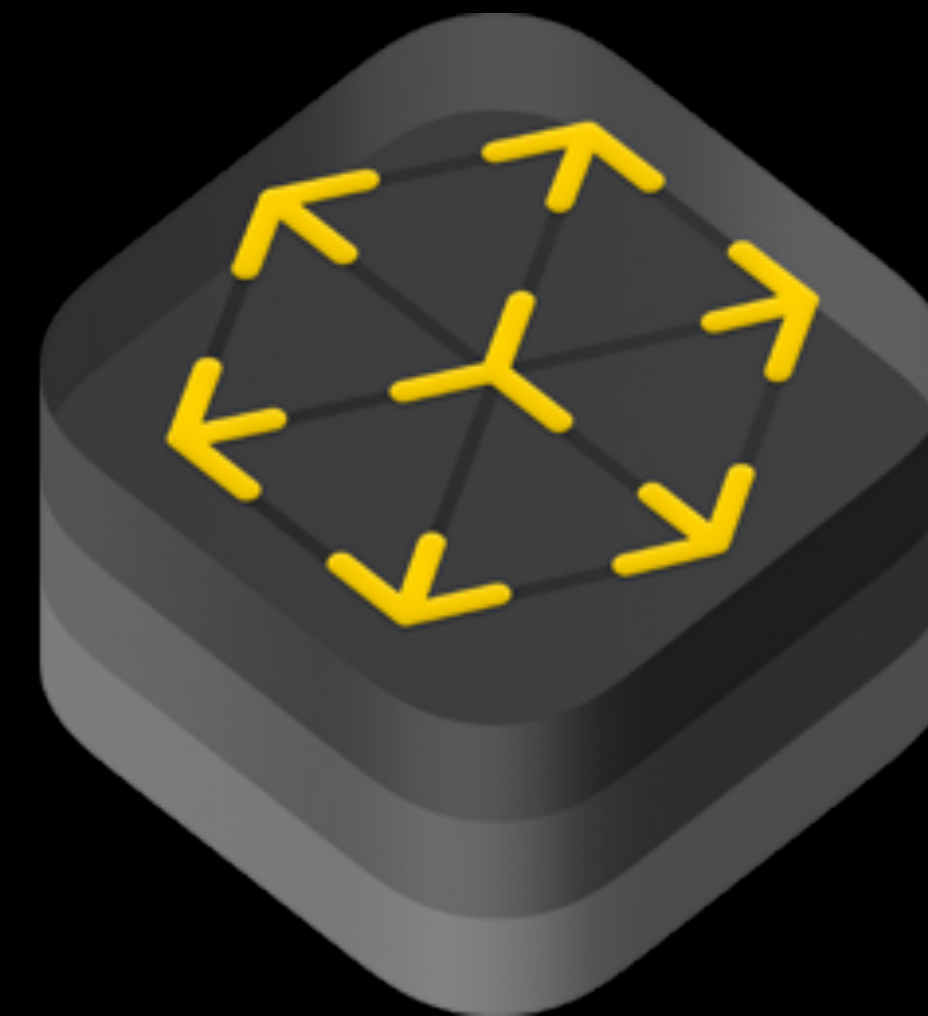
Mobile AR platform

High-level API

iOS (A9 and up)



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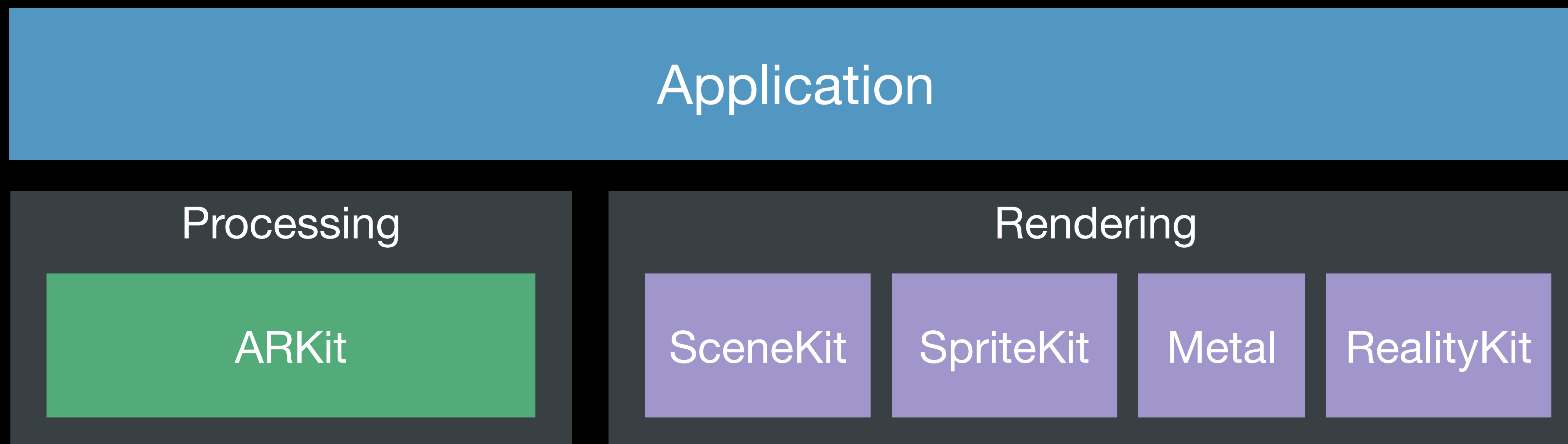


使用 ARKit

Behind AR Application

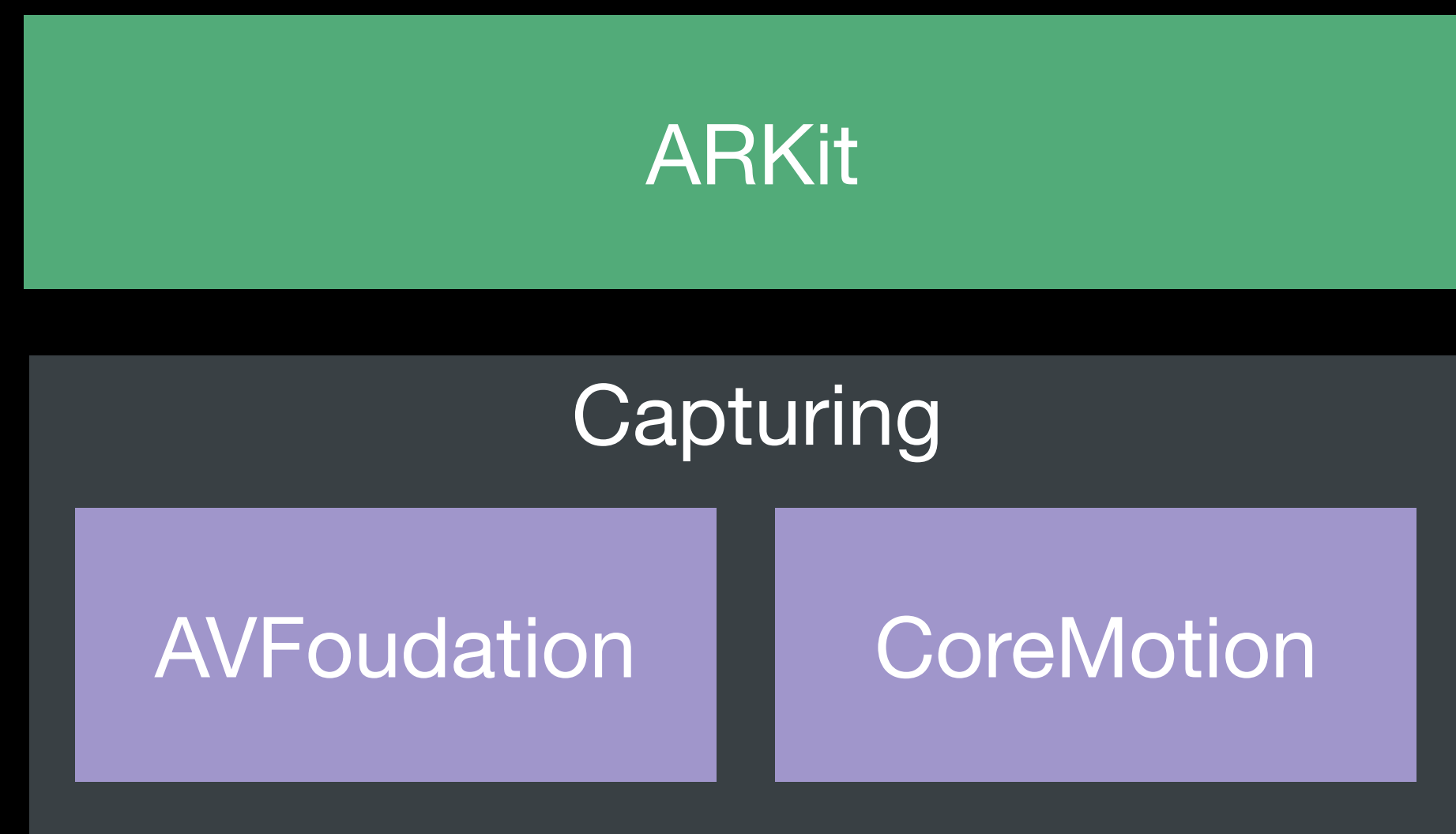


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使用 ARKit

Behind AR Application



使用 ARKit

Behind AR Application



ARSession

使用 ARKit

Behind AR Application



ARSessionConfiguration

ARSession

使用 ARKit

Behind AR Application



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```
run(_ configuration)
```

ARSessionConfiguration



ARSession

使用 ARKit

Behind AR Application



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```
run(_ configuration)
```

ARSessionConfiguration

ARSession

AVCaptureSession

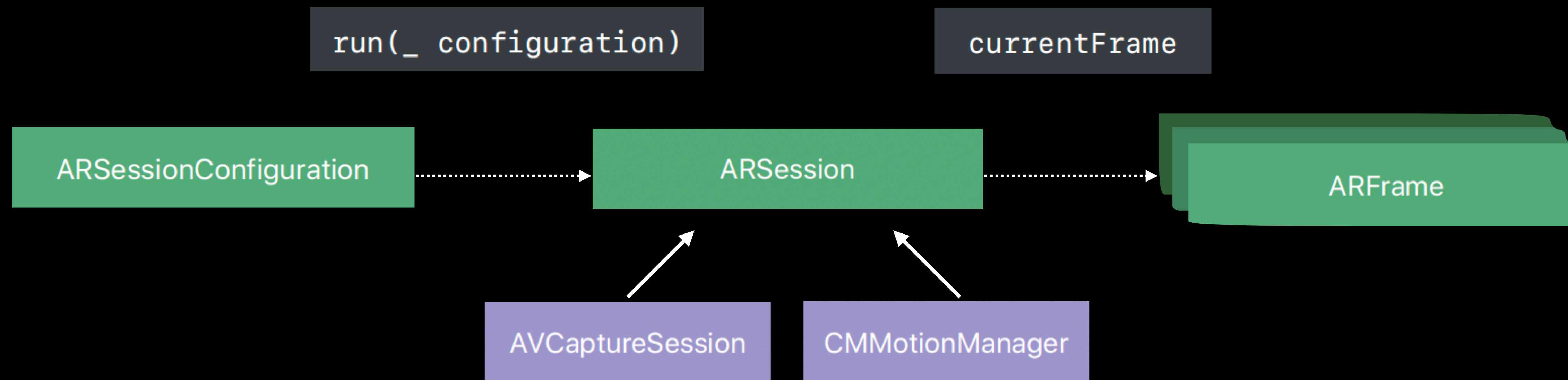
CMMotionManager

使用 ARKit

Behind AR Application



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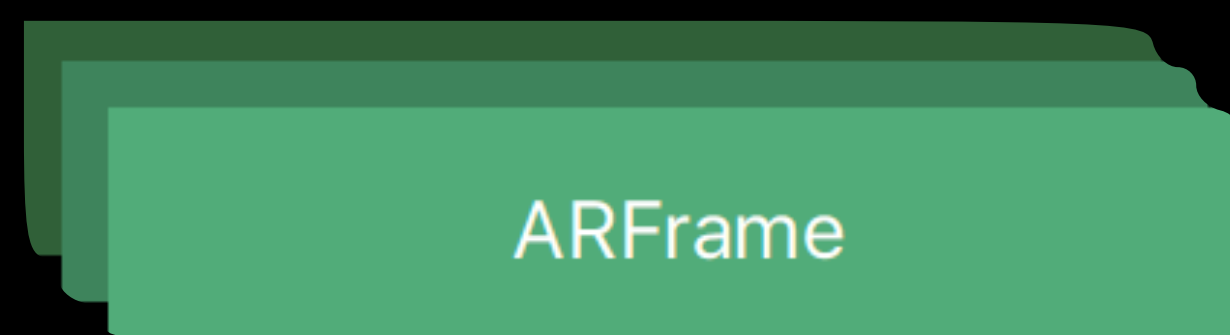


使用 ARKit

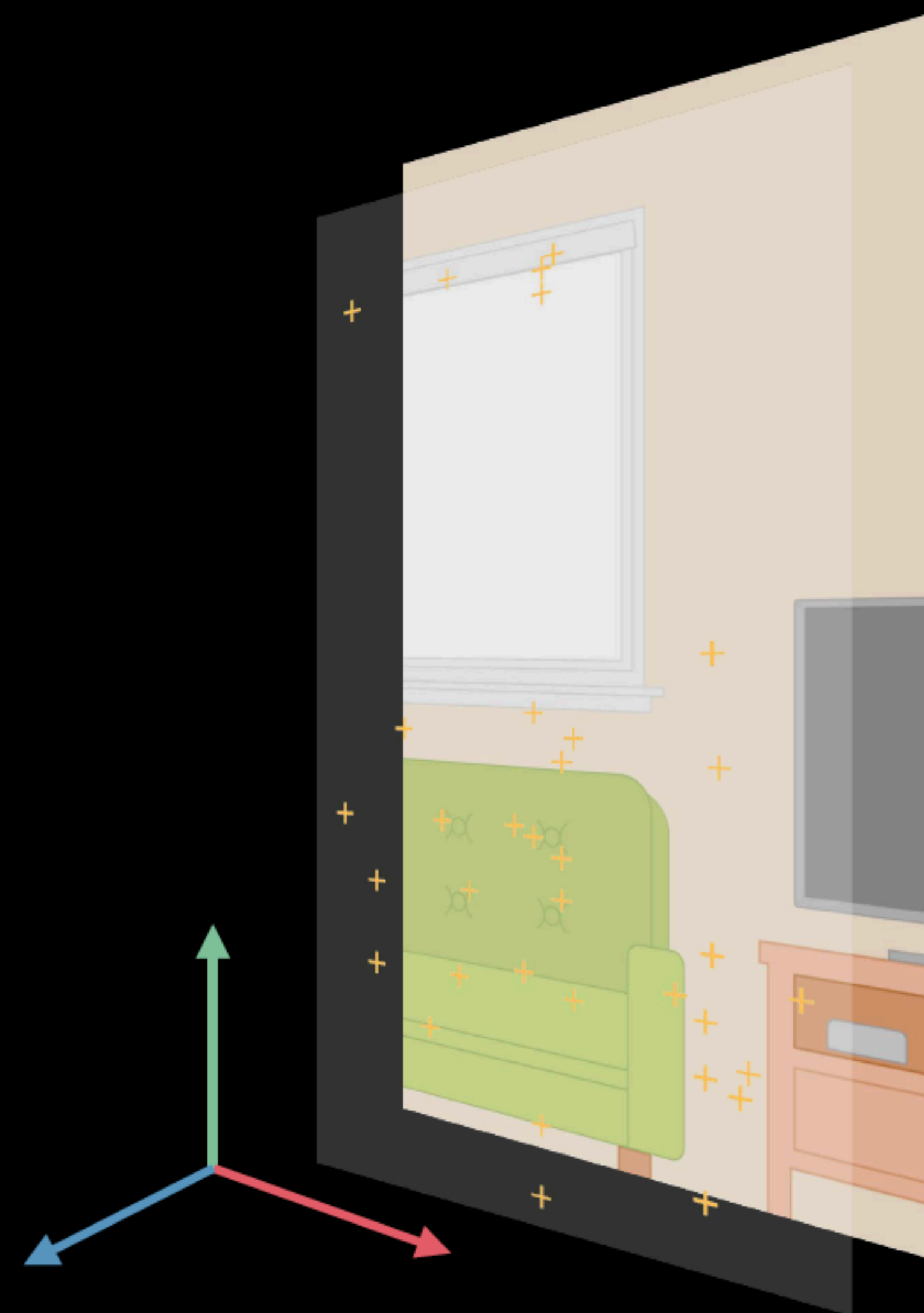
Behind AR Application



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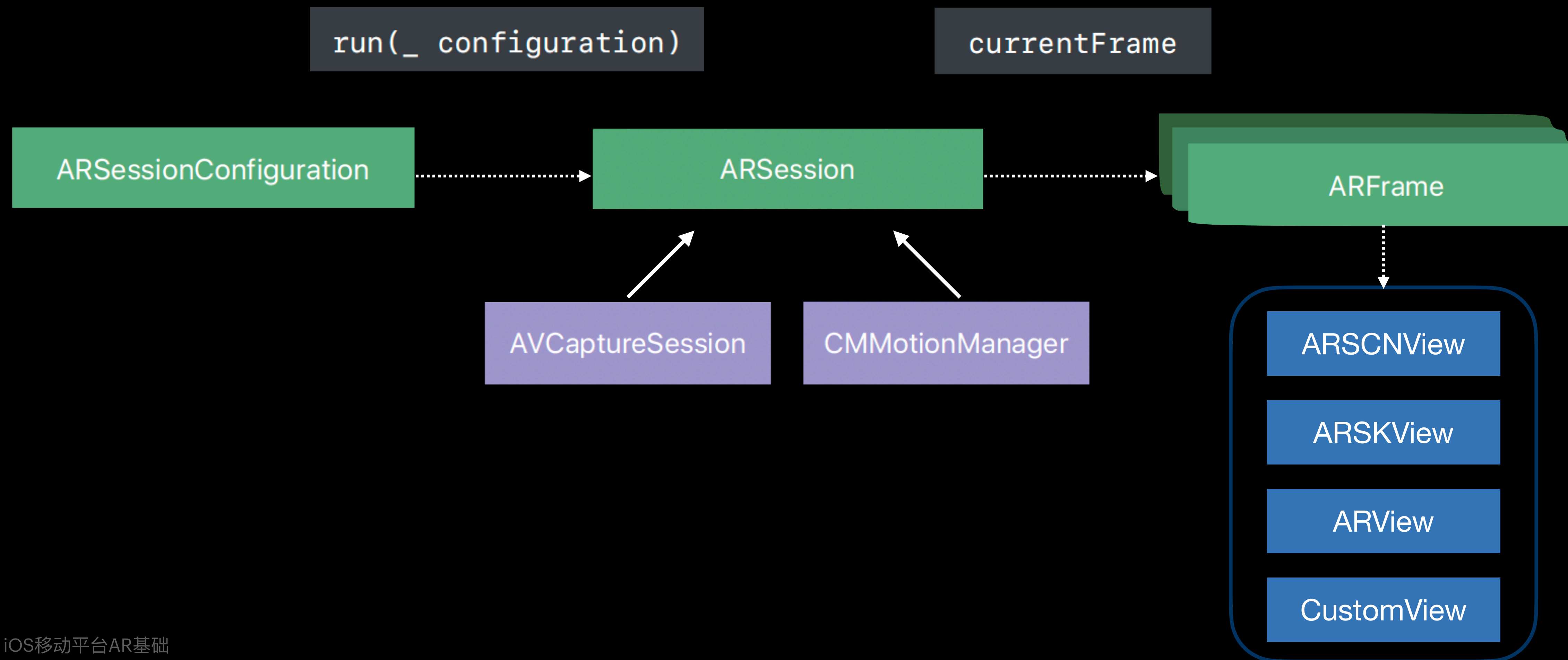


Captured image
Tracking information
Scene information



使用 ARKit

Behind AR Application



ARKit

ARKit Features



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Tracking



Scene Understanding



Rendering

ARKit - 跟踪

ARKit Features - Tracking



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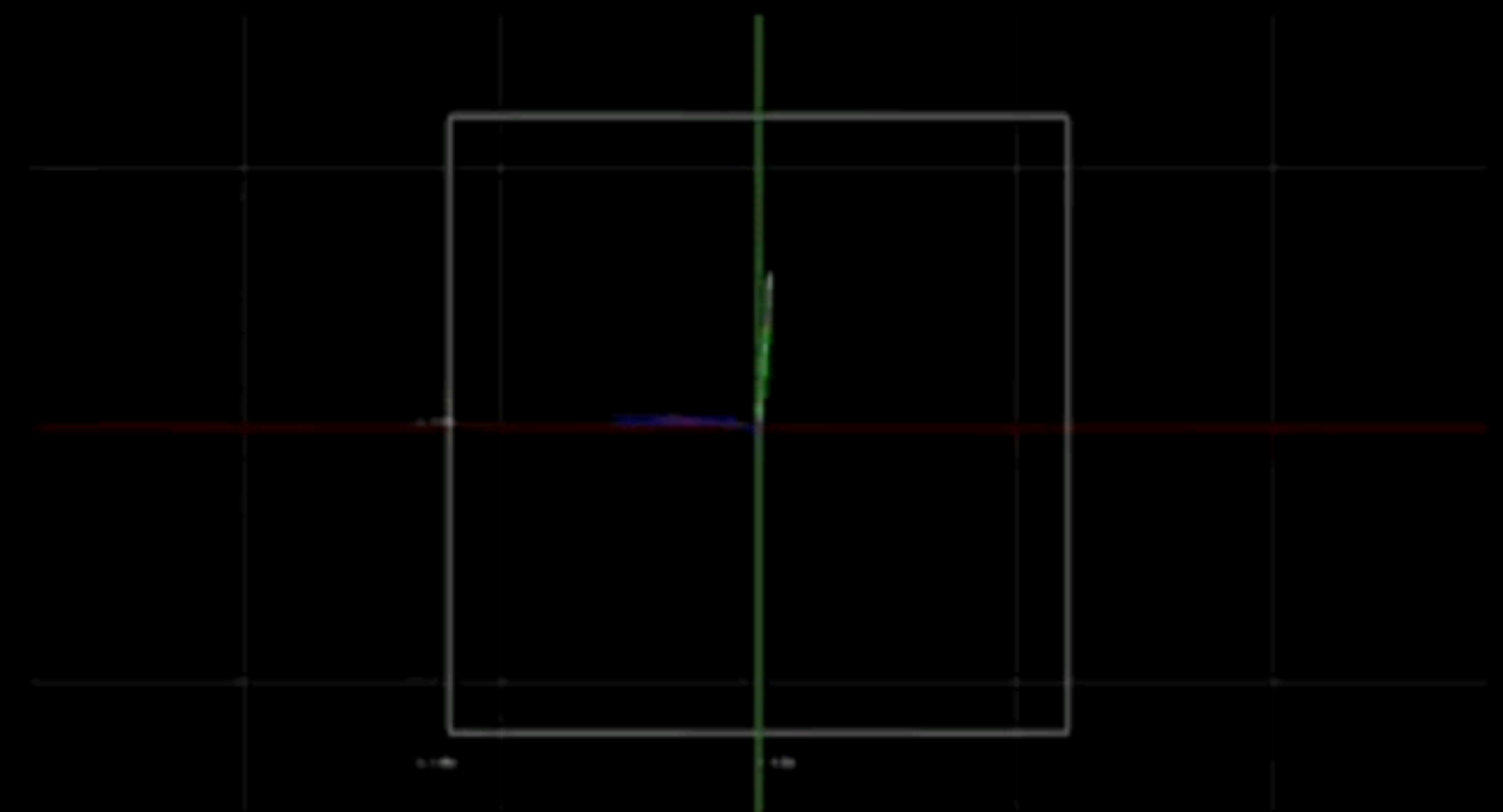


Tracking

World Tracking

Visual inertial odometry

No external setup



ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

图片跟踪

物体扫描

人体跟踪

地理位置跟踪

ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

ARKit 1

图片跟踪

物体扫描

人体跟踪

地理位置跟踪

ARKit - 跟踪

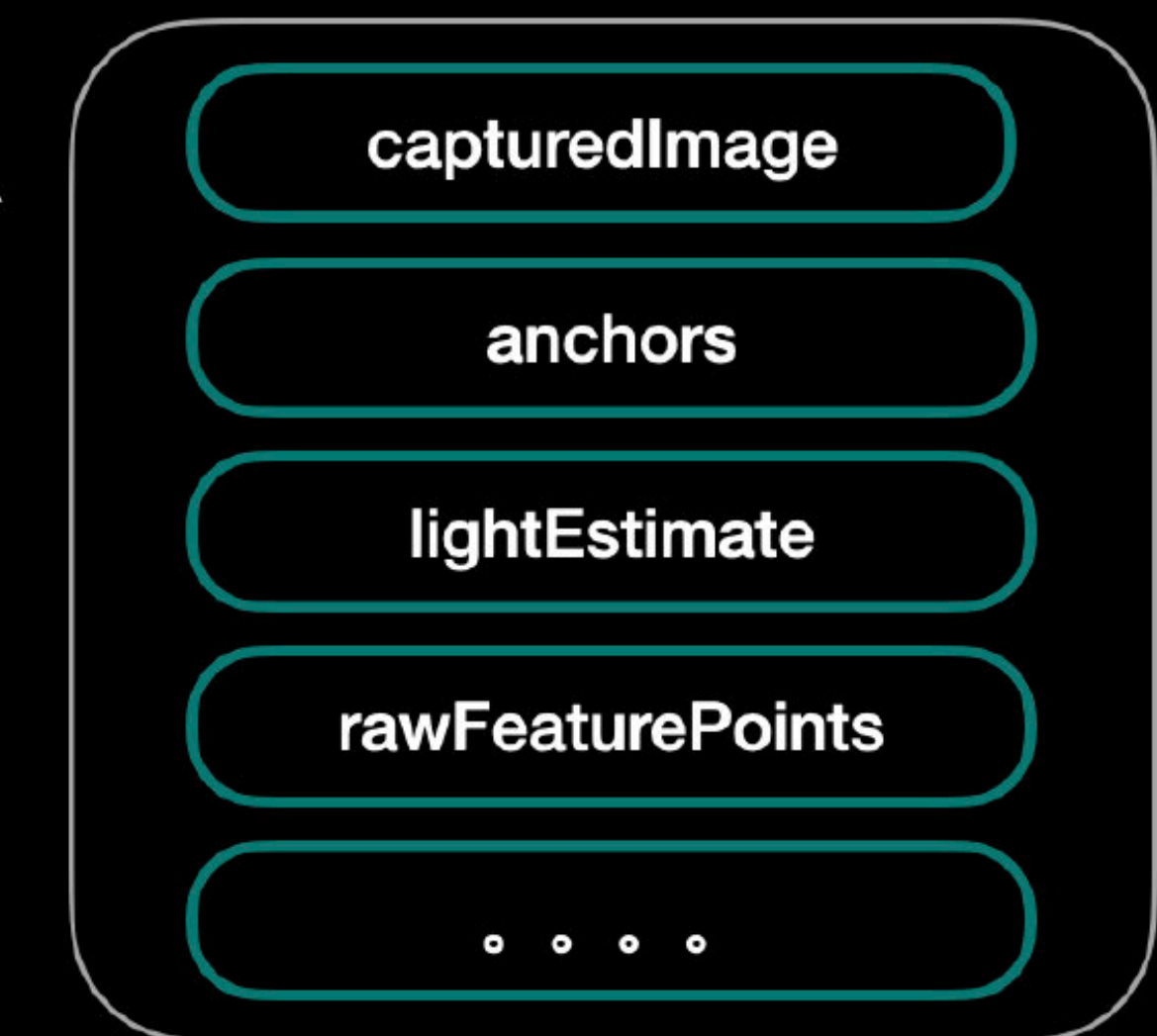
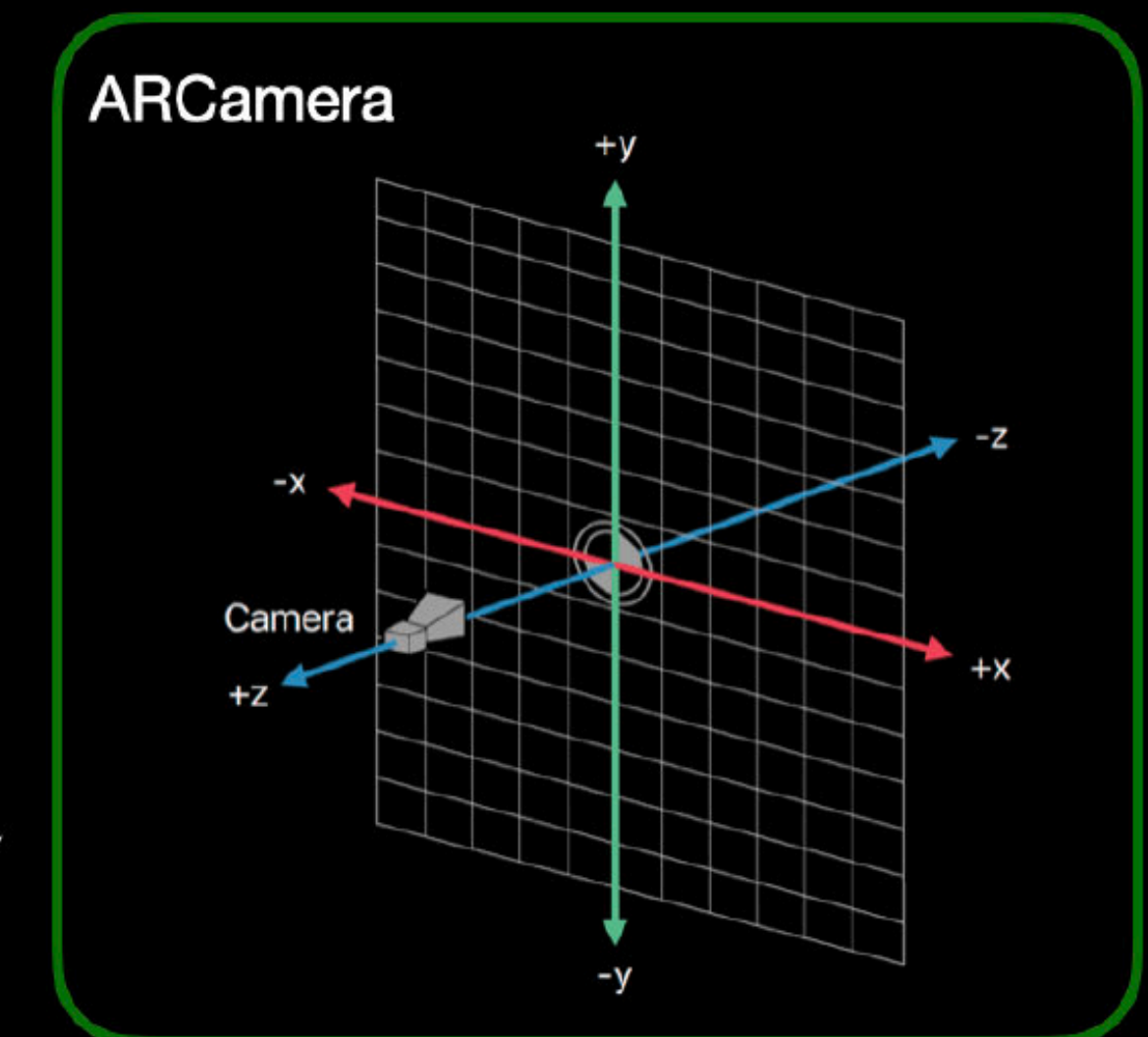
ARKit Features - Tracking

ARKit 1



世界跟踪

面部跟踪



使用 **ARWorldTrackingConfiguration** 来配置 **ARSession** 类，实时捕捉设备的位姿信息，解决跟踪问题

ARKit - 跟踪

ARKit Features - Tracking

ARKit 1



世界跟踪

面部跟踪

结合原深感摄像头（TrueDepth Camera），ARKit 可以实时跟踪面部状态，并以 60Hz 的频率输出面部的位置、拓扑和表情信息。



ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

图片跟踪

物体扫描

人体跟踪

地理位置跟踪

ARKit 2

ARKit - 跟踪

ARKit 2

ARKit Features - Tracking



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世界跟踪

ARWorldMap

面部跟踪

图片跟踪

物体扫描

- 映射物理空间
- 锚点列表
- 点云和范围



ARKit - 跟踪 ARKit 2

ARKit Features - Tracking



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世界跟踪

凝视跟踪

面部跟踪

- leftEyeTransform
- rightEyeTransform
- lookAtPoint

图片跟踪

物体扫描

舌头检测

- ARBlendShapeLocation



ARKit - 跟踪

ARKit Features - Tracking

ARKit 2



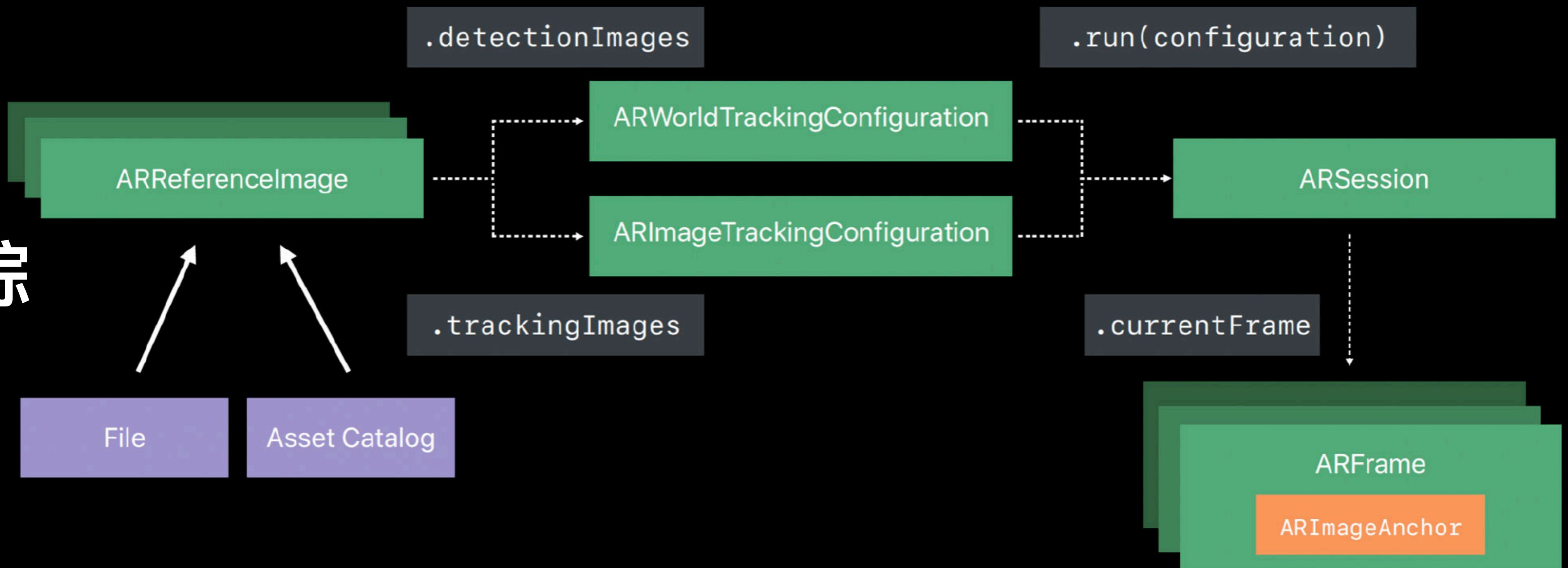
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世界跟踪

面部跟踪

图片跟踪

物体扫描



ARKit - 跟踪

ARKit Features - Tracking

ARKit 2



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世界跟踪

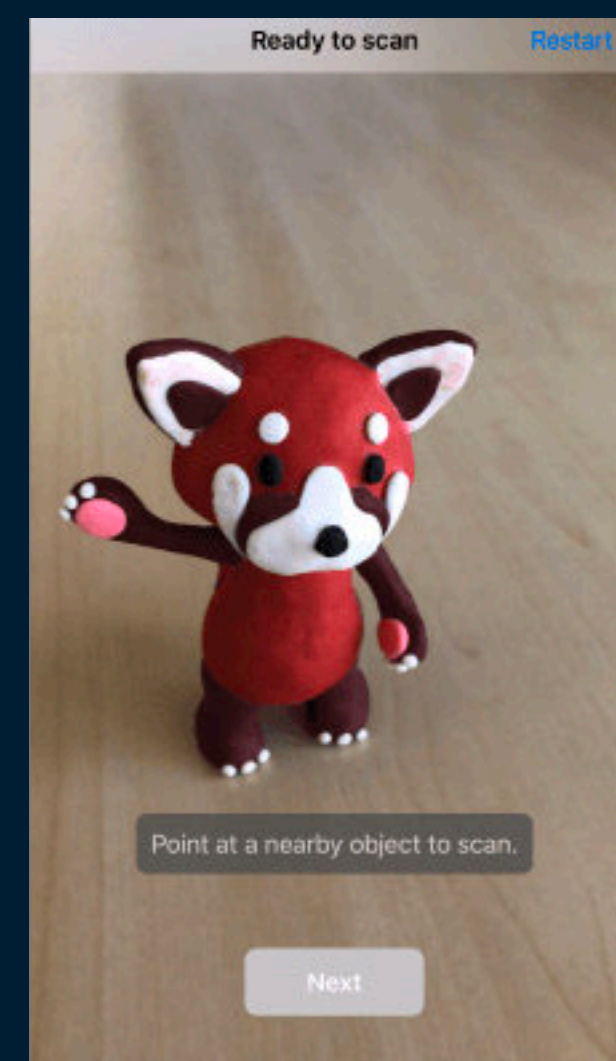
- 检测

面部跟踪

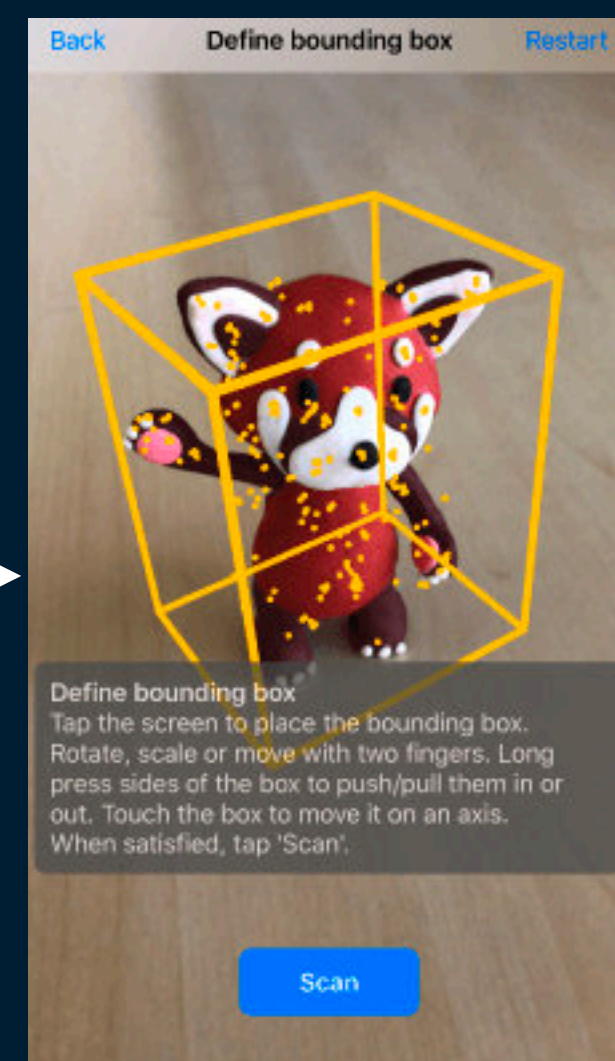
- 扫描

图片跟踪

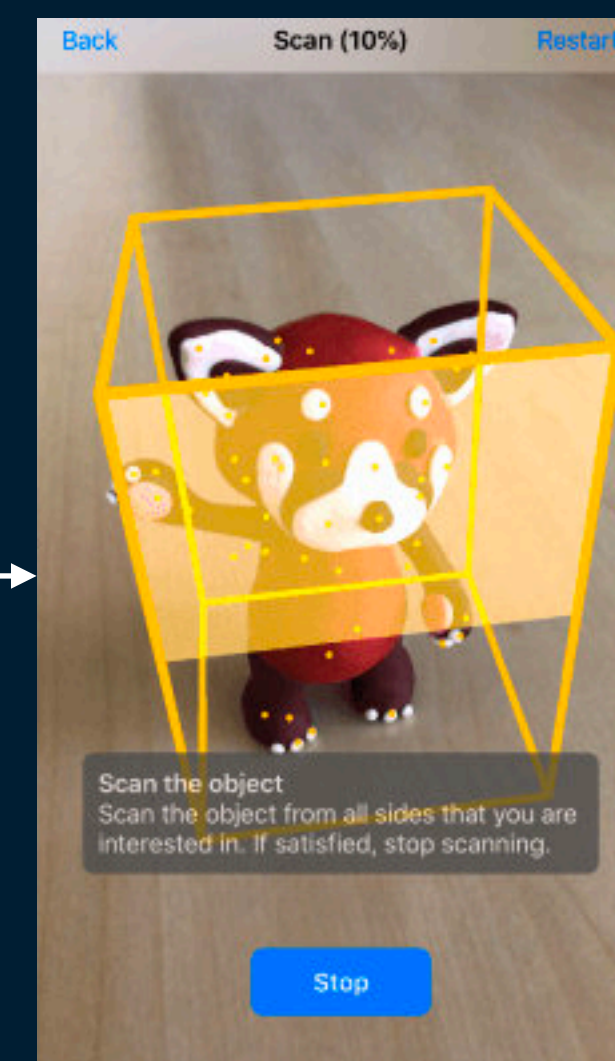
物体扫描



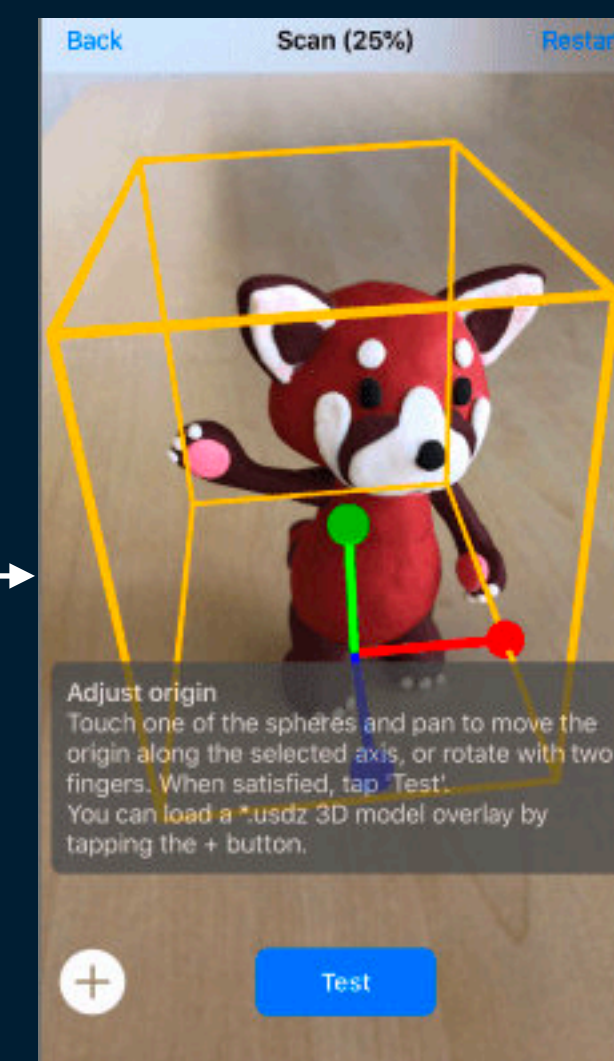
Prepare to scan



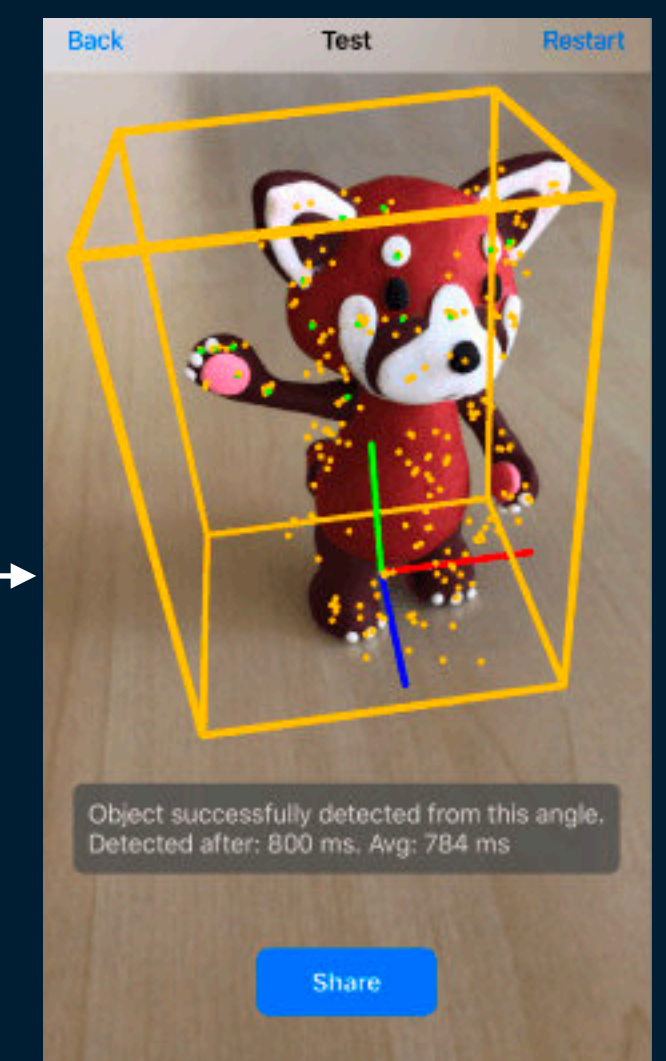
Define bounding box



Scan



Adjust origin



Test and Export

ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

图片跟踪

物体扫描

人体跟踪

地理位置跟踪

ARKit 3

ARKit - 跟踪

ARKit 3

ARKit Features - Tracking



世界跟踪

会话协作 Collaborative Sessions

面部跟踪

人体跟踪



Session A



Session B

ARKit - 跟踪

ARKit 3

ARKit Features - Tracking



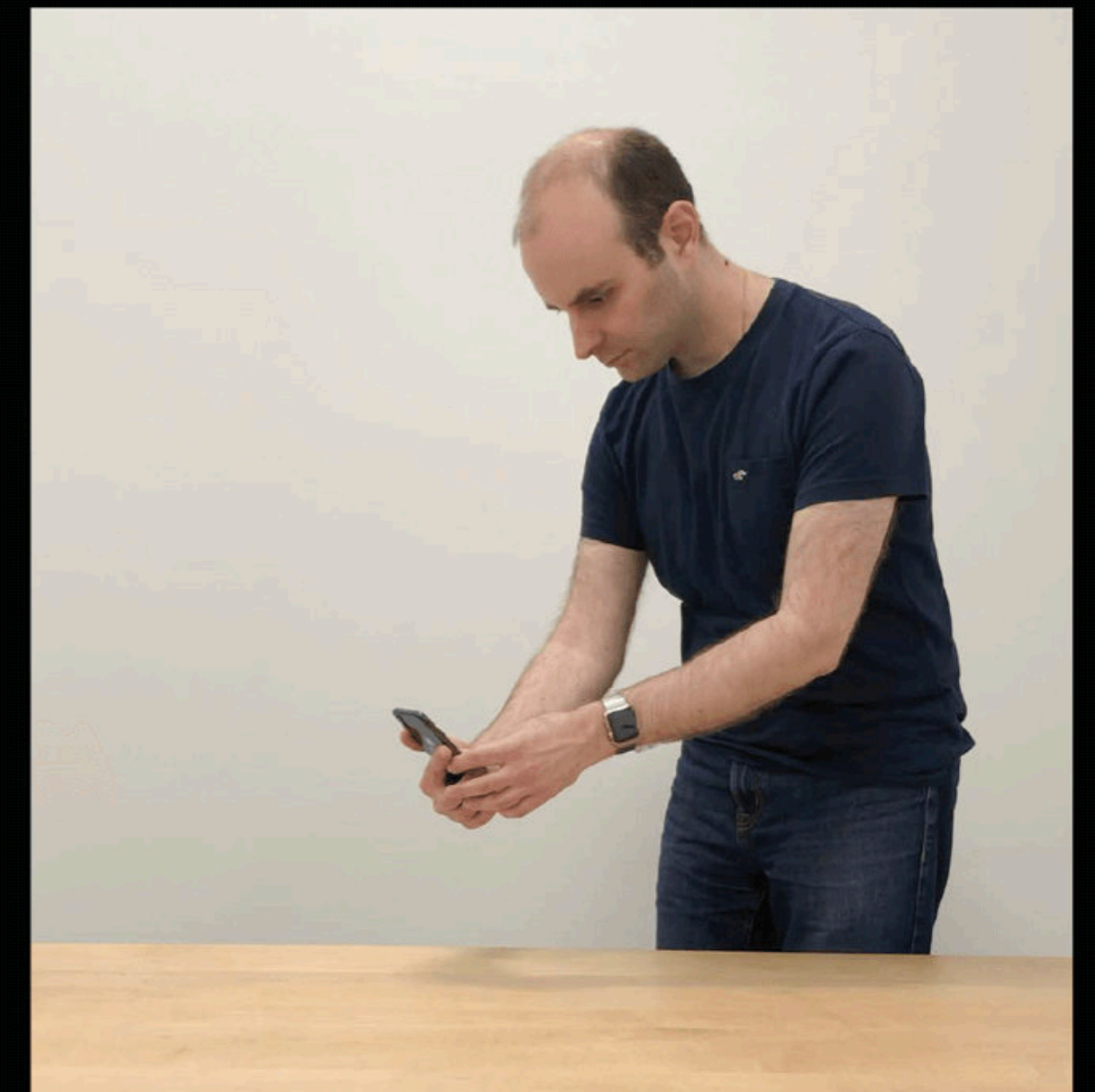
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世界跟踪

面部跟踪

人体跟踪

- 同时开启前置和后置摄像头来进行世界跟踪和面部跟踪
- 同时跟踪多张人脸



ARKit - 跟踪

ARKit Features - Tracking

ARKit 3

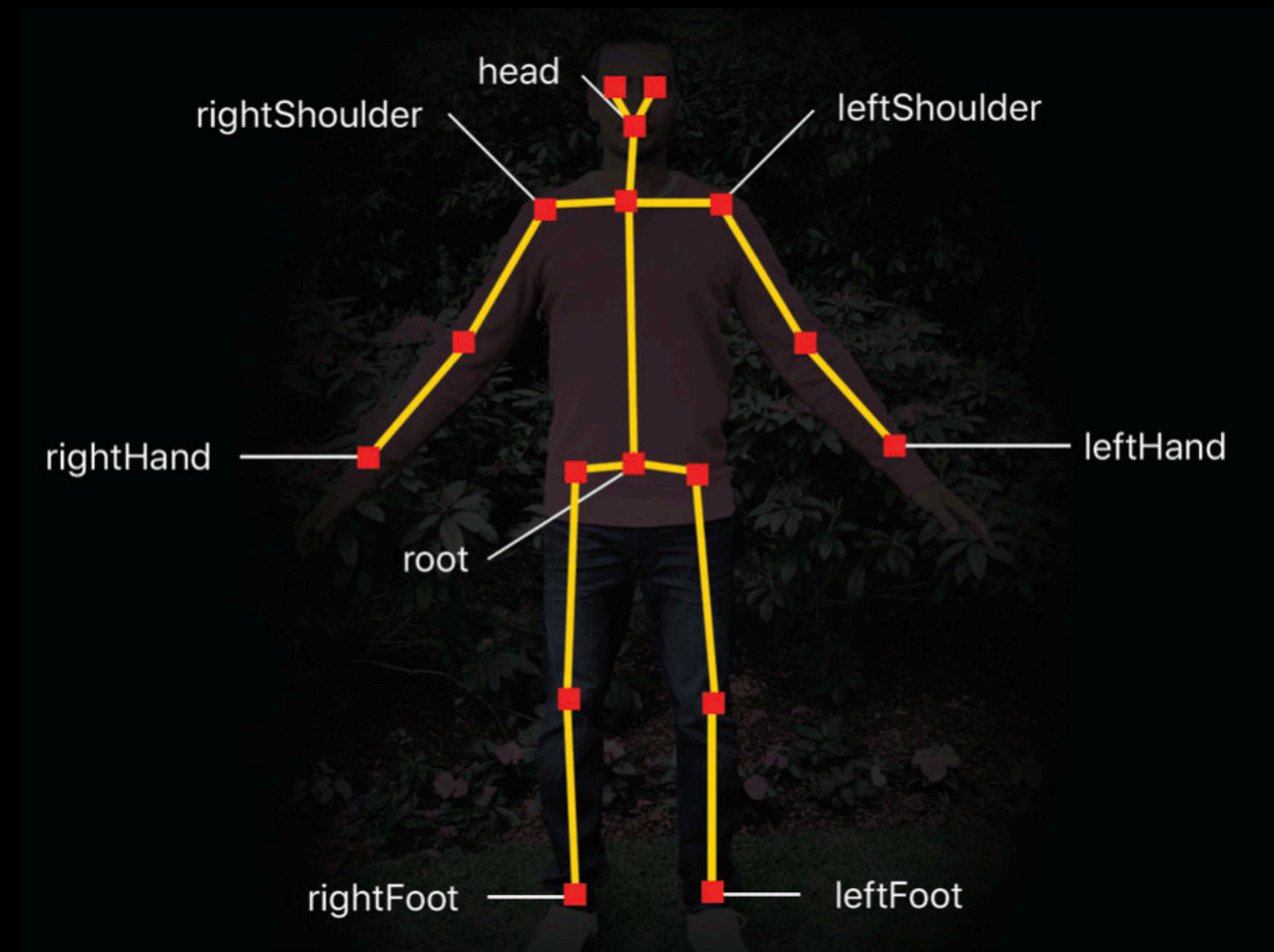


世界跟踪

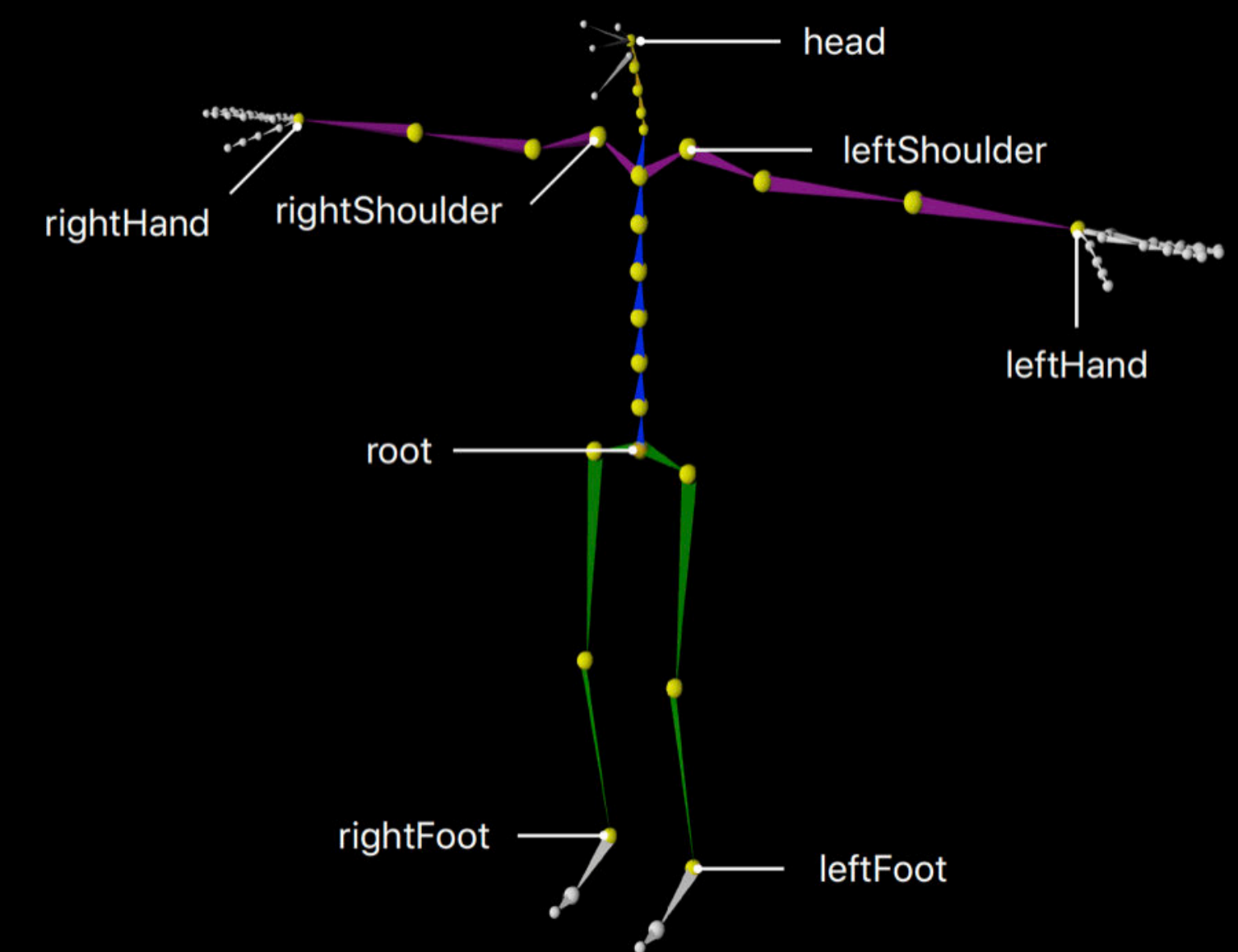
面部跟踪

人体跟踪

依赖于机器学习，可以在 capturedImage 中识别人体骨骼结构，会跟踪人体 2D 和 3D 骨骼信息。



2D 骨骼



3D 骨骼

ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

图片跟踪

物体扫描

人体跟踪

地理位置跟踪 ARKit 4

ARKit - 跟踪 ARKit 4

ARKit Features - Tracking

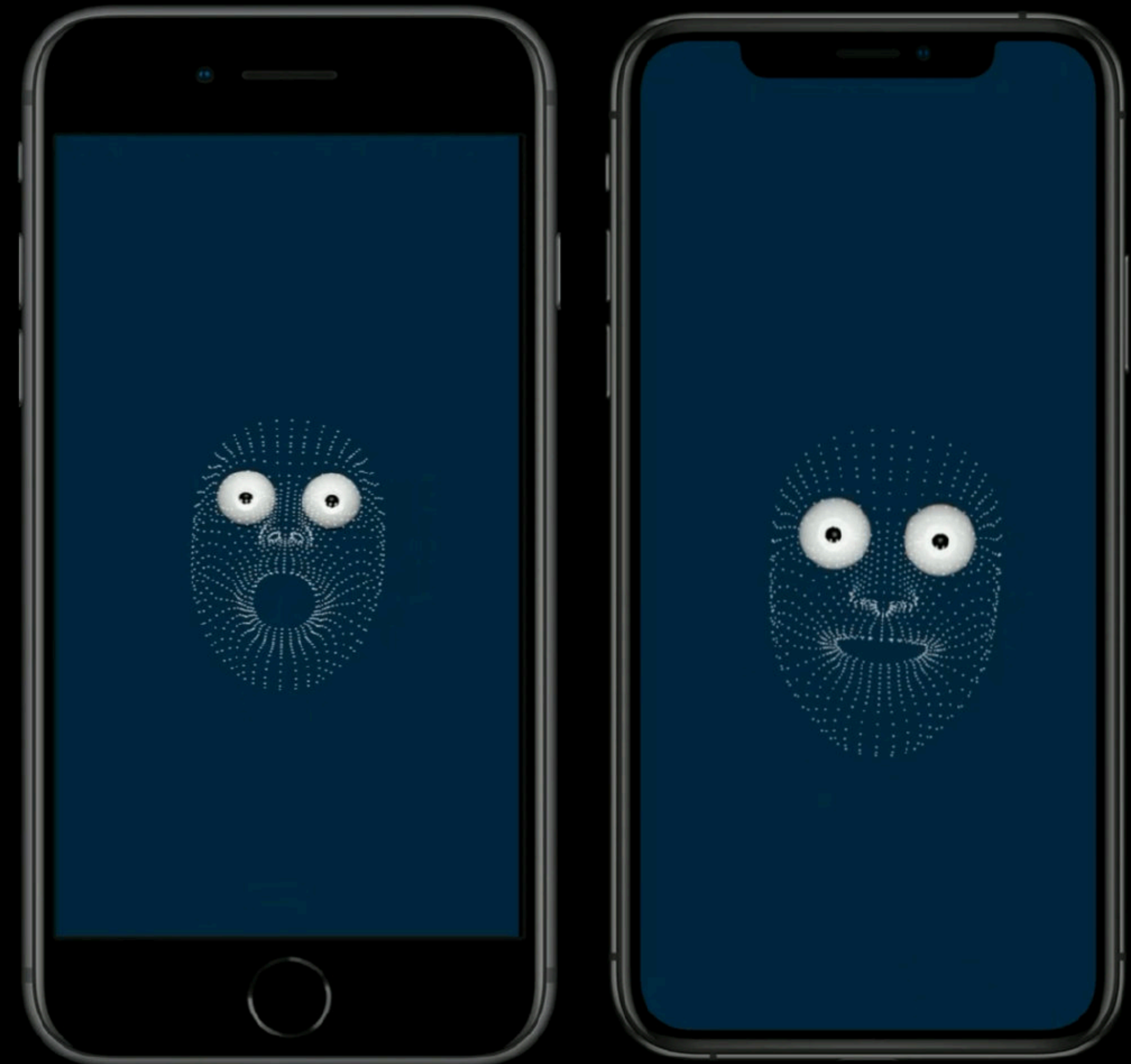


面部跟踪 扩展支持

地理位置跟踪

- A12 CPU及以上
- 不包含depth data

	TrueDepth camera	A12 or later
Face anchors	✓	✓
Face geometry	✓	✓
Blendshapes	✓	✓
Captured depth data	✓	✗



ARKit - 跟踪 ARKit 4

ARKit Features - Tracking



面部跟踪 指全球范围内可支持城市的坐标点

地理位置跟踪

地理位置跟踪步骤：

1. 检查设备支持情况，如果支持则运行 session
2. 添加位置锚点 (ARGeoAnchor)
3. 实时监听地理跟踪状态



ARKit - 跟踪

ARKit Features - Tracking



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世界跟踪

面部跟踪

图片跟踪

物体扫描

ARKit 5

人体跟踪

地理位置跟踪

ARKit - 跟踪

ARKit Features - Tracking

ARKit 5



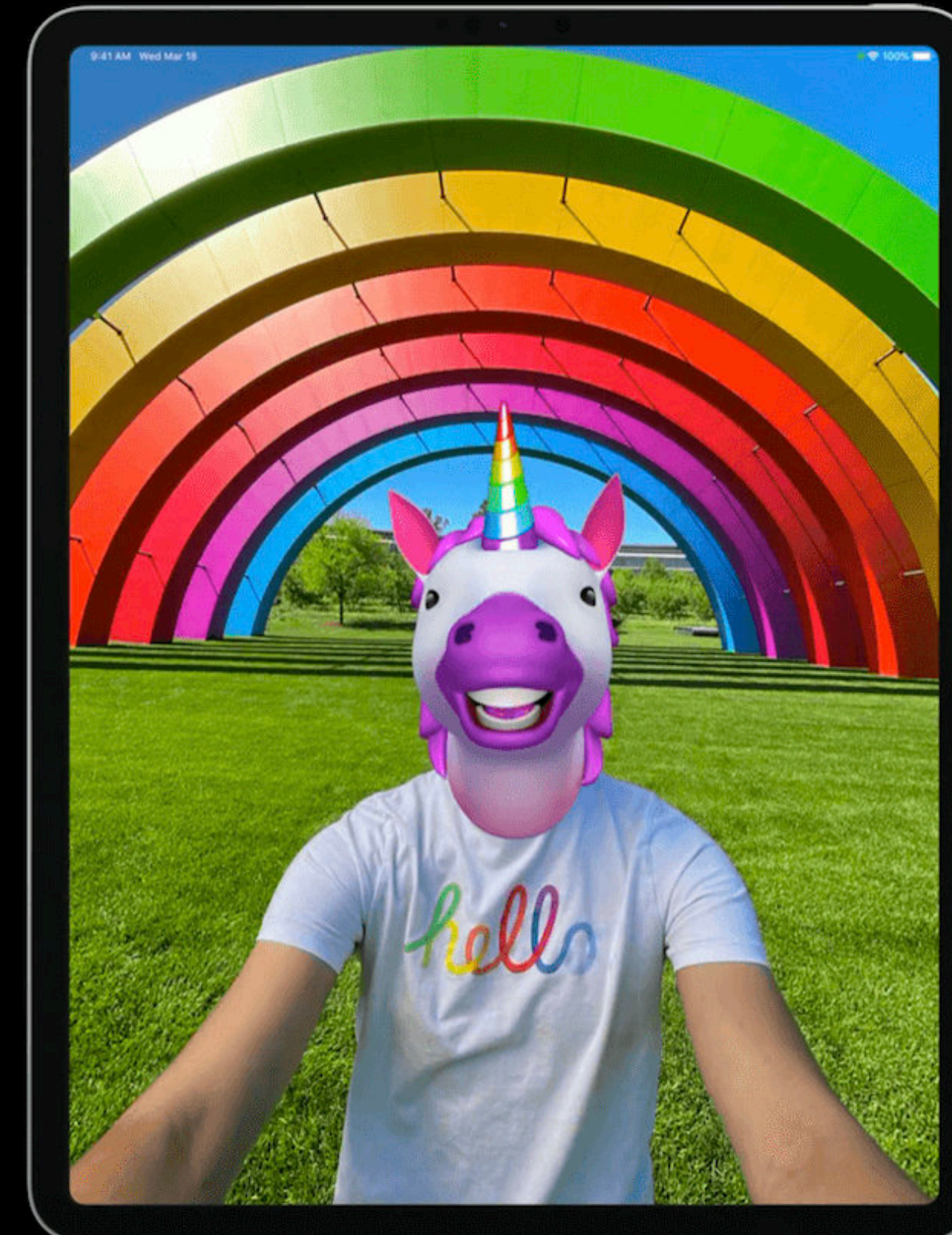
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面部跟踪

超广角格式 ultra-wide video format

人体跟踪

地理位置跟踪



ARKit - 跟踪

ARKit Features - Tracking

面部跟踪

人体跟踪

地理位置跟踪

ARKit 5



- 支持更广泛的身体姿势
- 识别与跟踪效果提升



ARKit - 跟踪

ARKit Features - Tracking

面部跟踪

人体跟踪

地理位置跟踪

另外在 ARKit5 和 之后的ARKit6 中,
Location Anchor 支持了更多的城市

ARKit 5

路线规划 turn-by-turn



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ARKit - 跟踪

ARKit Features - Tracking



跟踪类型	跟踪类	发布版本	系统要求
世界跟踪	ARWorldTrackingConfiguration	ARKit1	iOS 11
方向跟踪	AROrientationTrackingConfiguration	ARKit1	iOS 11
面部跟踪	ARFaceTrackingConfiguration	ARKit1	iOS 11
图片跟踪	ARImageTrackingConfiguration	ARKit2	iOS 12
物体扫描	ARObjectScanningConfiguration	ARKit2	iOS 12
人体跟踪	ARBodyTrackingConfiguration	ARKit3	iOS 13
位置跟踪	ARPositionalTrackingConfiguration	ARKit3	iOS 13
地理位置跟踪	ARGeoTrackingConfiguration	ARKit4	iOS 14

ARKit - 理解

ARKit Features - Scene Understanding



Scene Understanding

Plane detection

Hit-testing

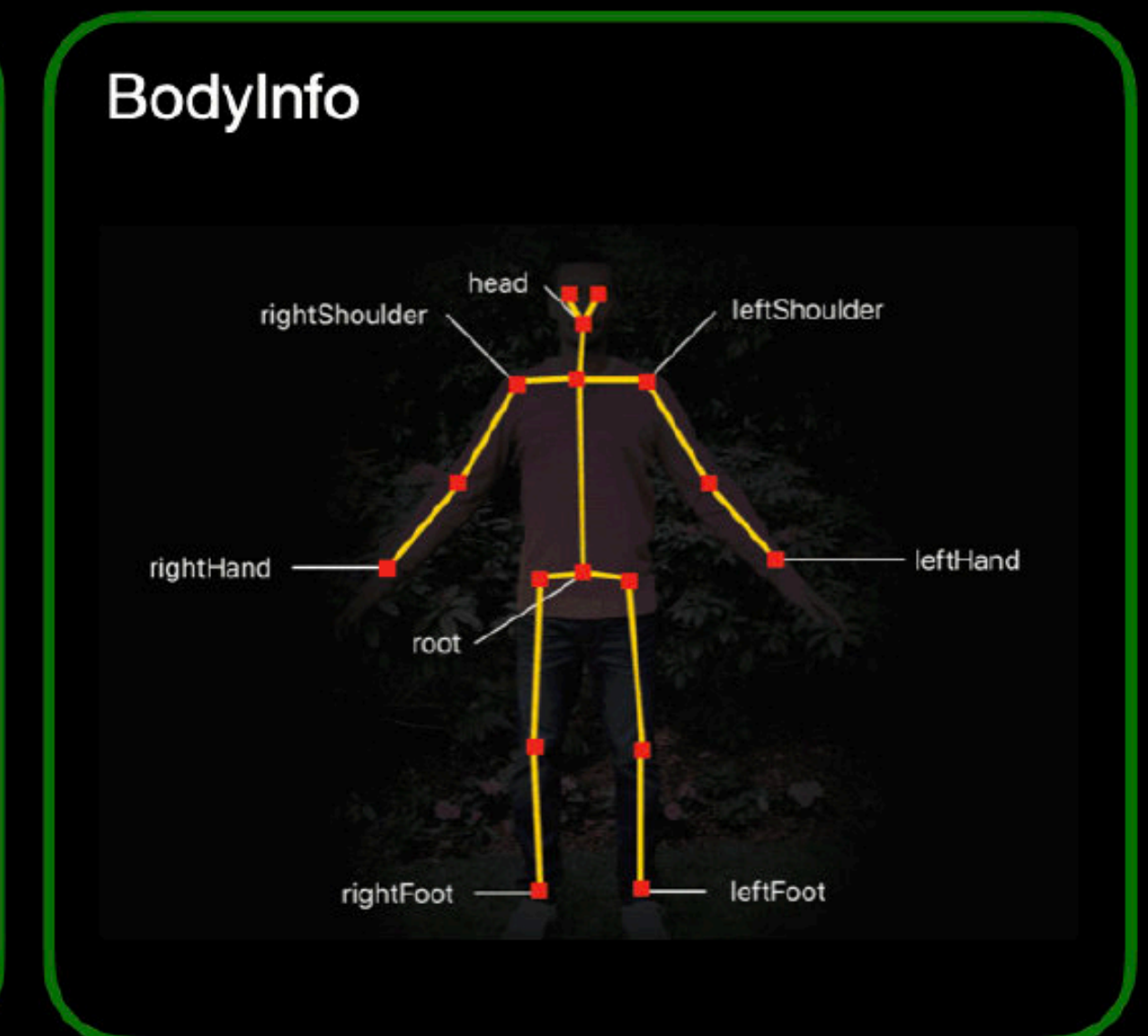
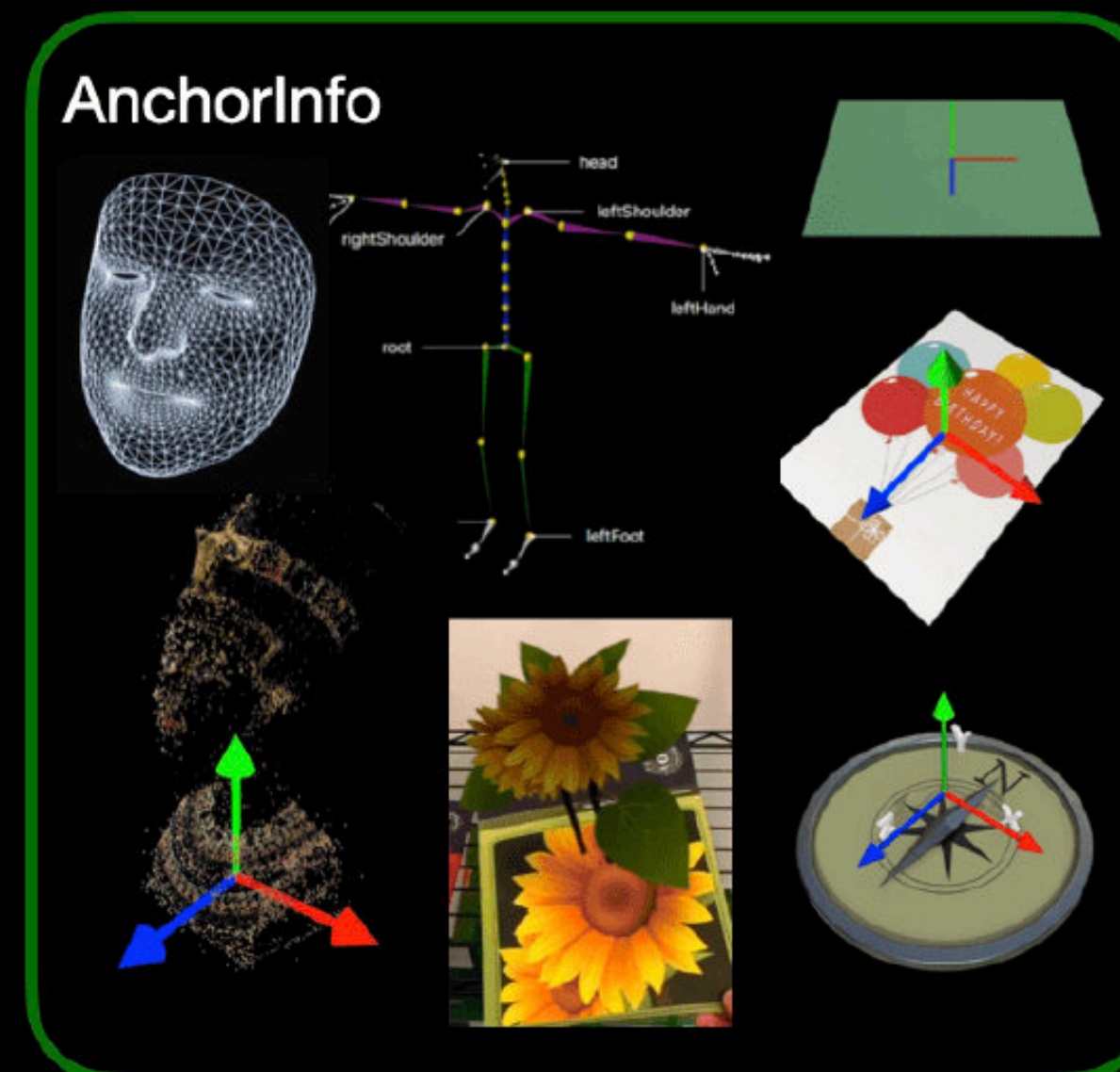
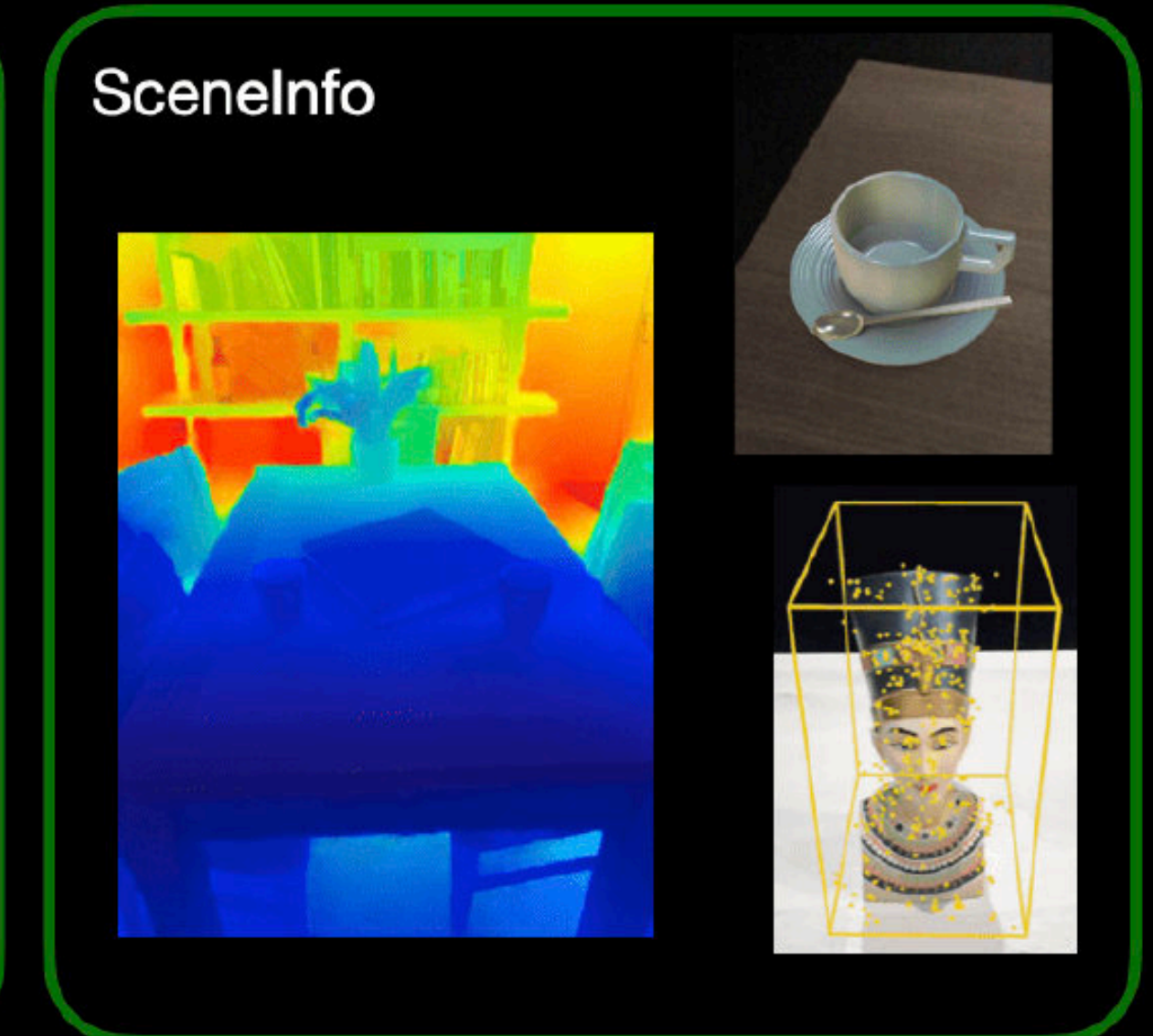
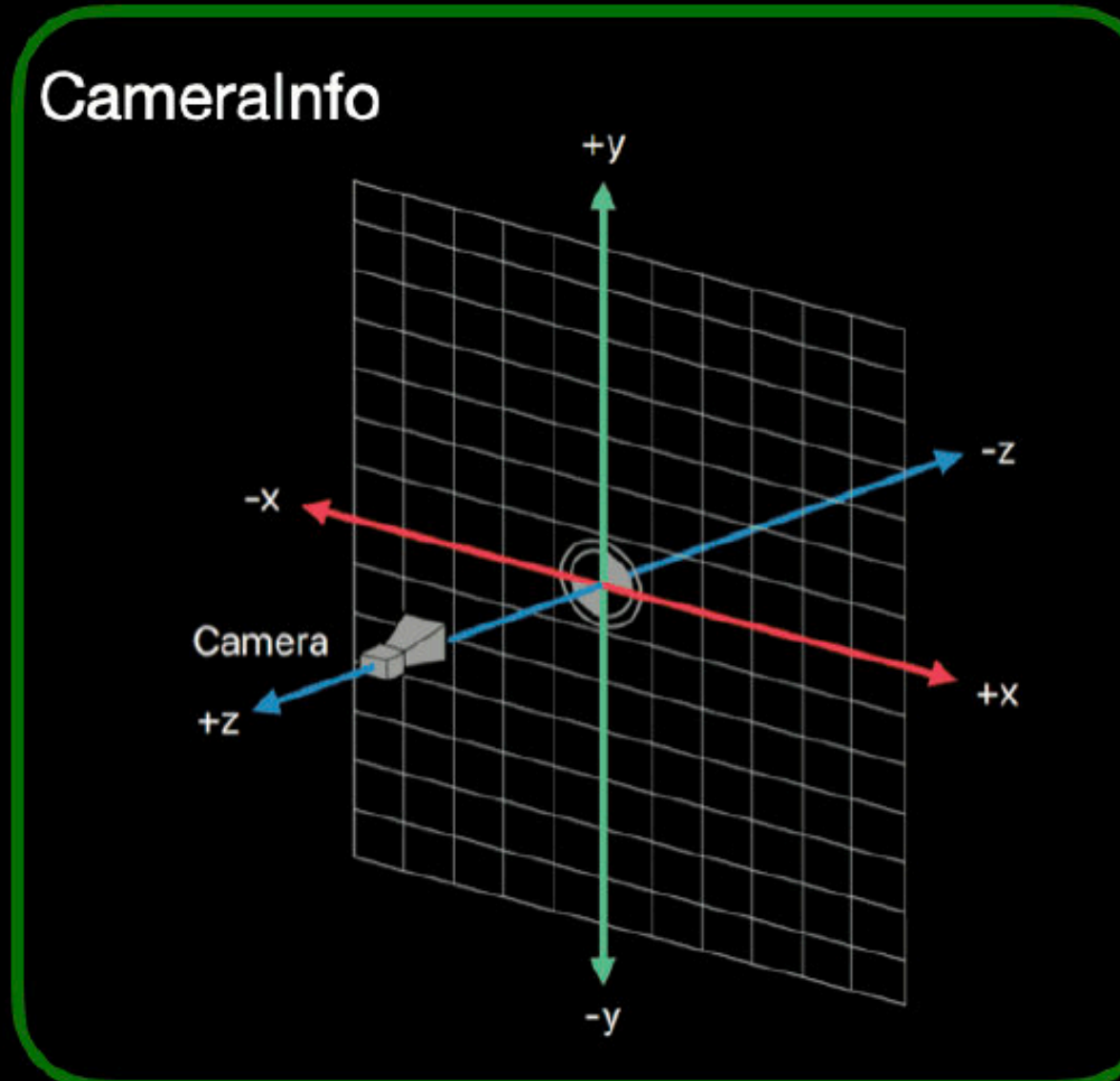
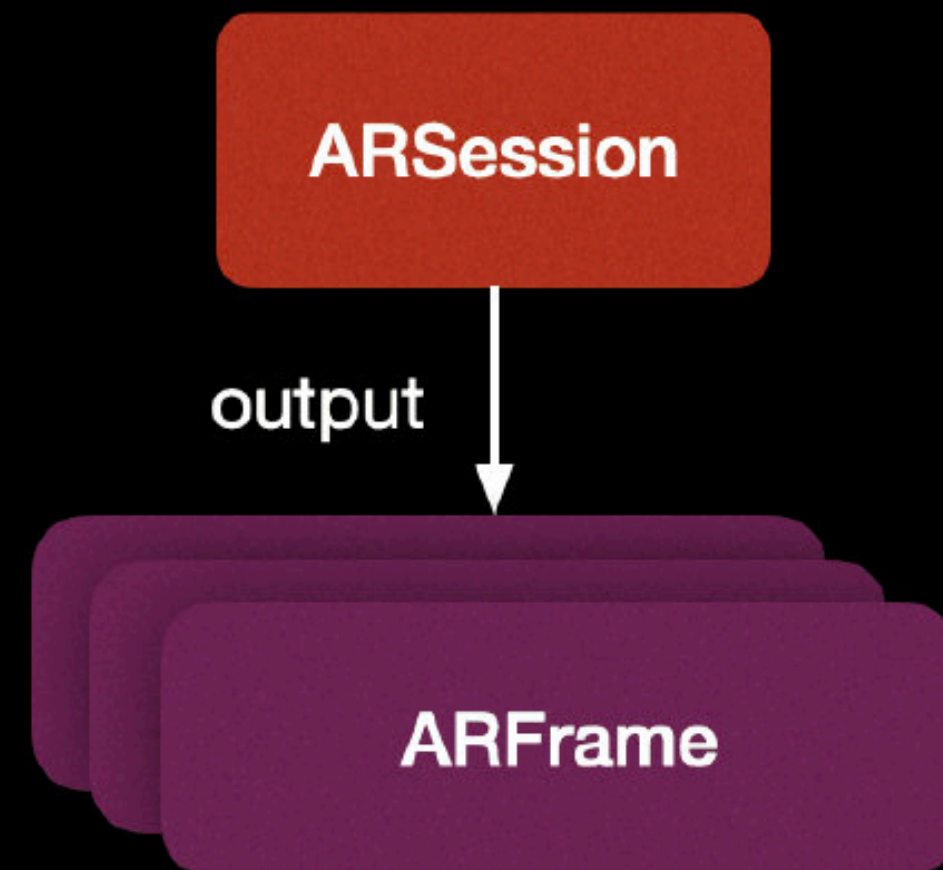
Light estimation

ARKit - 理解

ARKit Features - Scene Understanding

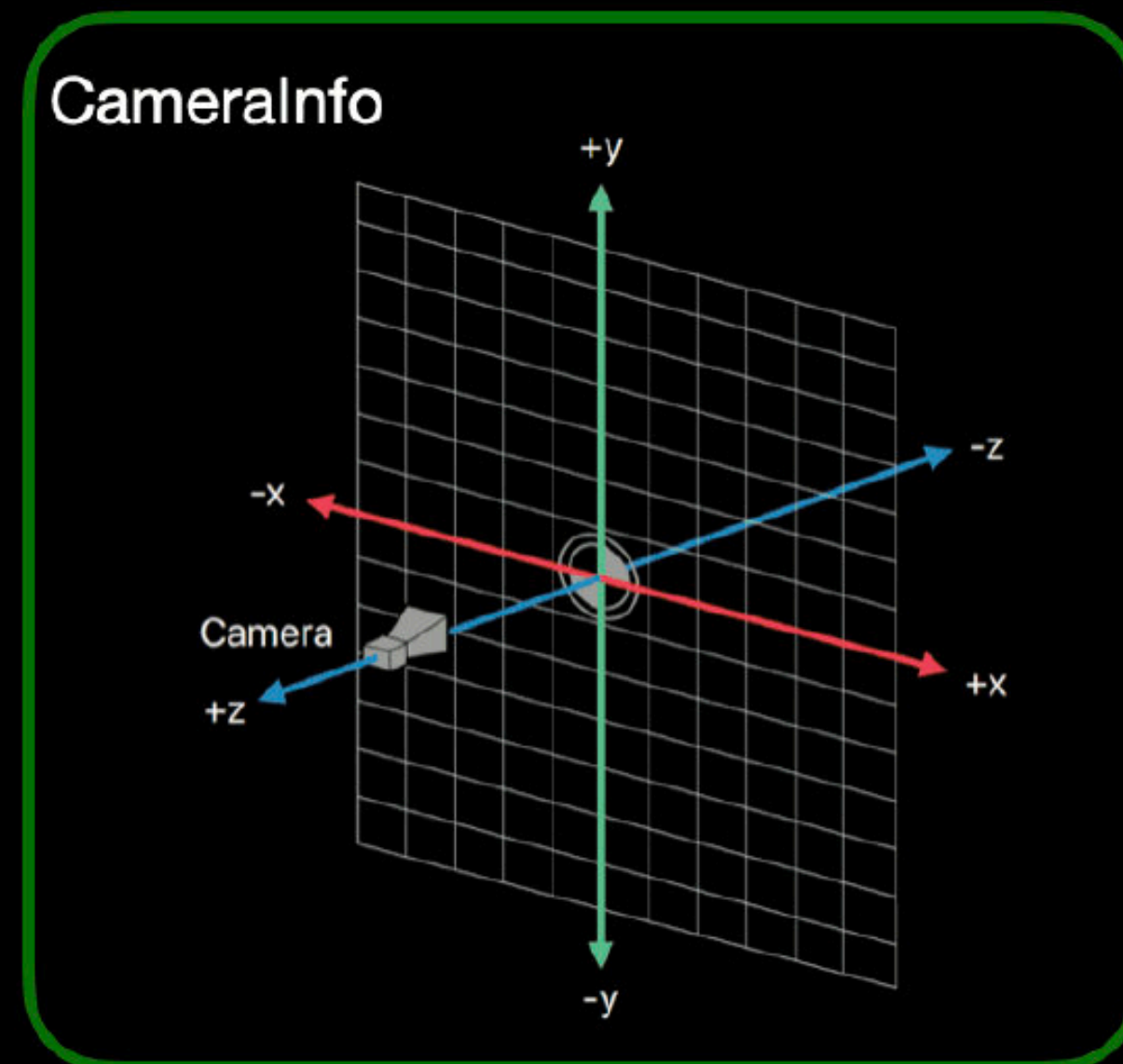


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ARKit - 理解

ARKit Features - Scene Understanding



相机信息

```
// frame 时间戳
open var timestamp: TimeInterval { get }

// 相机 EXIF 标签信息
@available(iOS 16.0, *)
open var exifData: [String : Any] { get }

// 相机噪点纹理
@available(iOS 13.0, *)
open var cameraGrainTexture: MTLTexture? { get }

// 相机噪点强度
@available(iOS 13.0, *)
open var cameraGrainIntensity: Float { get }

// 背景图像
open var capturedImage: CVPixelBuffer { get }

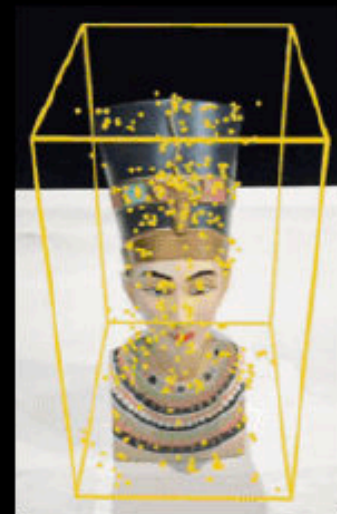
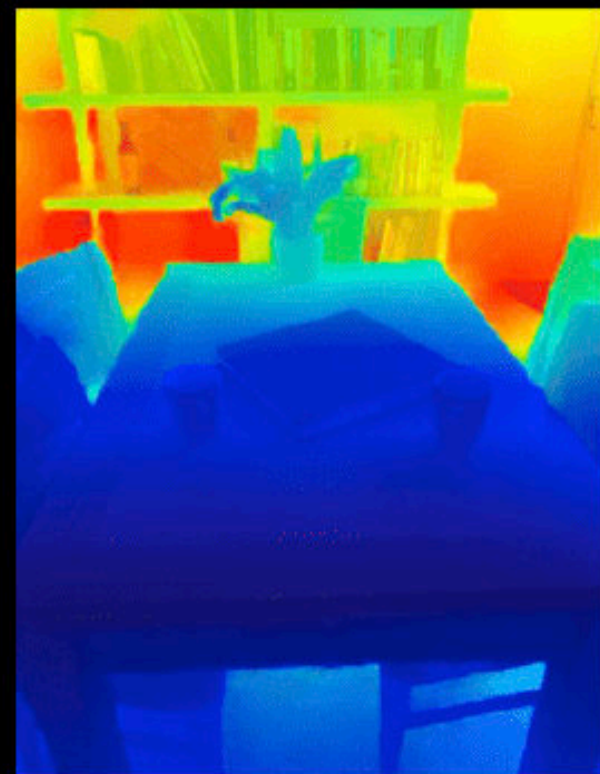
// 相机
open var camera: ARCamera { get }
```

ARKit - 理解

ARKit Features - Scene Understanding



SceneInfo



场景信息

```
// 光照
open var lightEstimate: ARLightEstimate? { get }

// 点云
open var rawFeaturePoints: ARPointCloud? { get }

// 前置原深感相机捕捉到的深度信息 以及 相应的时间戳
open var capturedDepthData: AVDepthData? { get }
open var capturedDepthDataTimestamp: TimeInterval { get }

// 场景深度数据
@available(iOS 14.0, *)
open var sceneDepth: ARDepthData? { get }

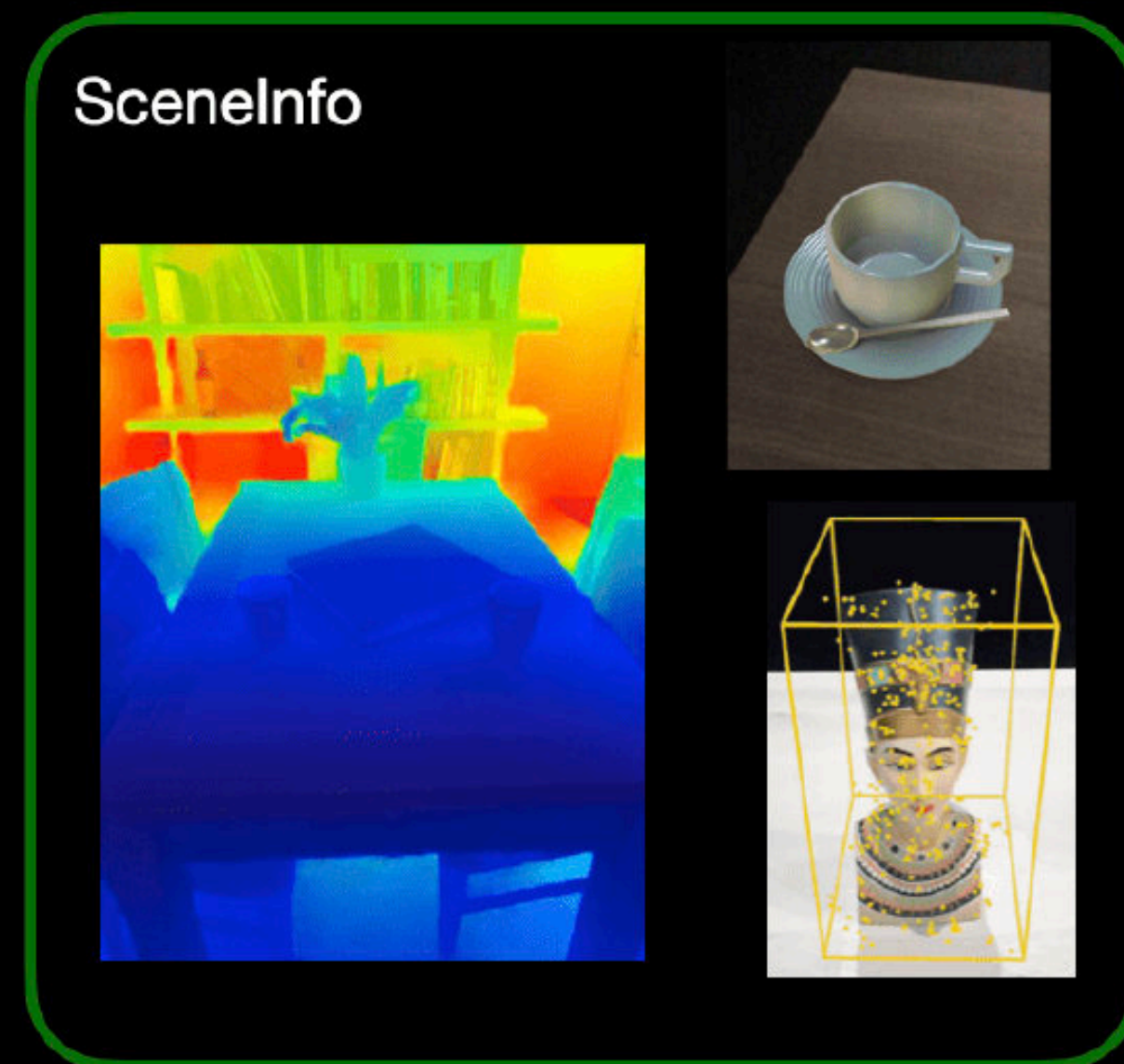
// 优化后的场景深度数据
@available(iOS 14.0, *)
open var smoothedSceneDepth: ARDepthData? { get }
```


ARKit - 理解

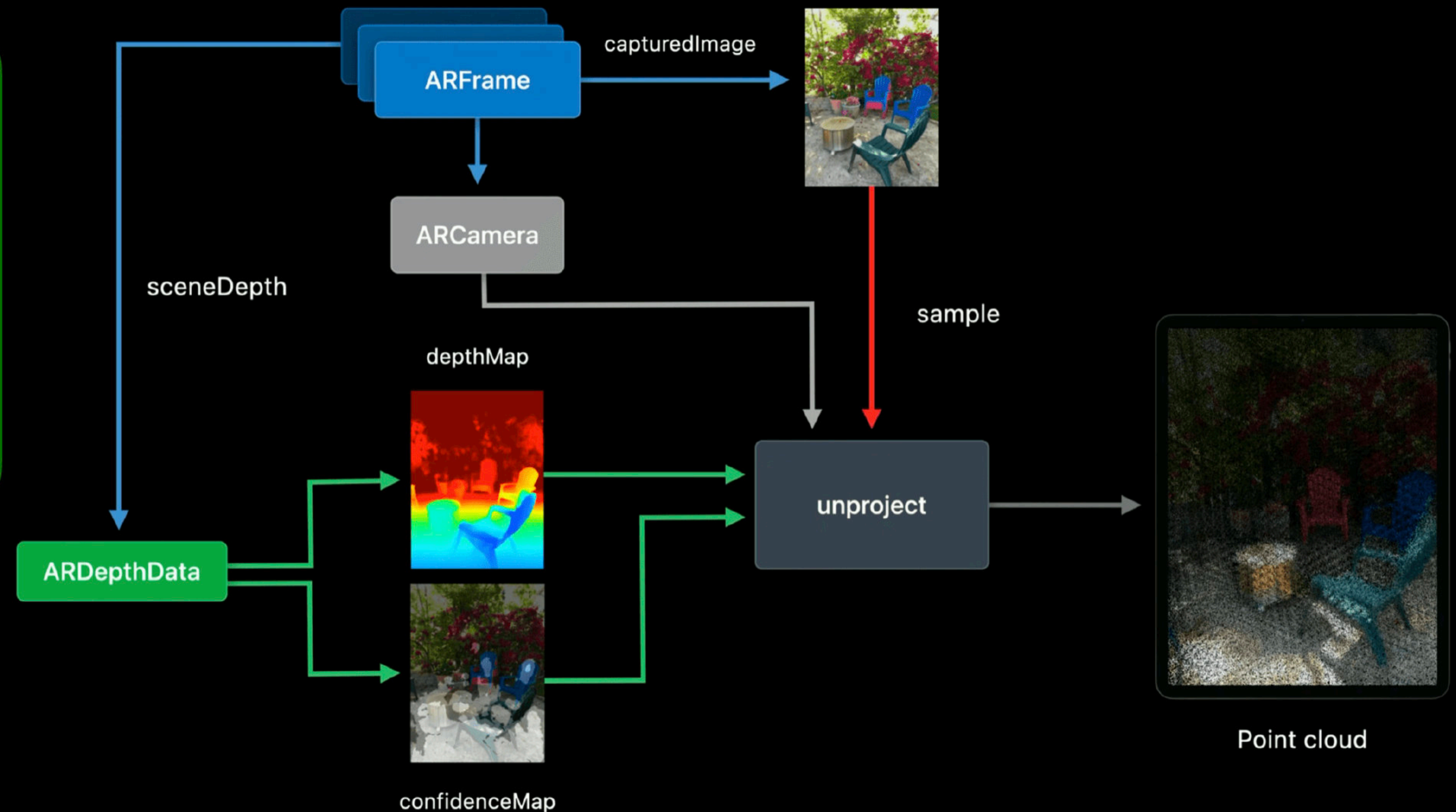
ARKit Features - Scene Understanding



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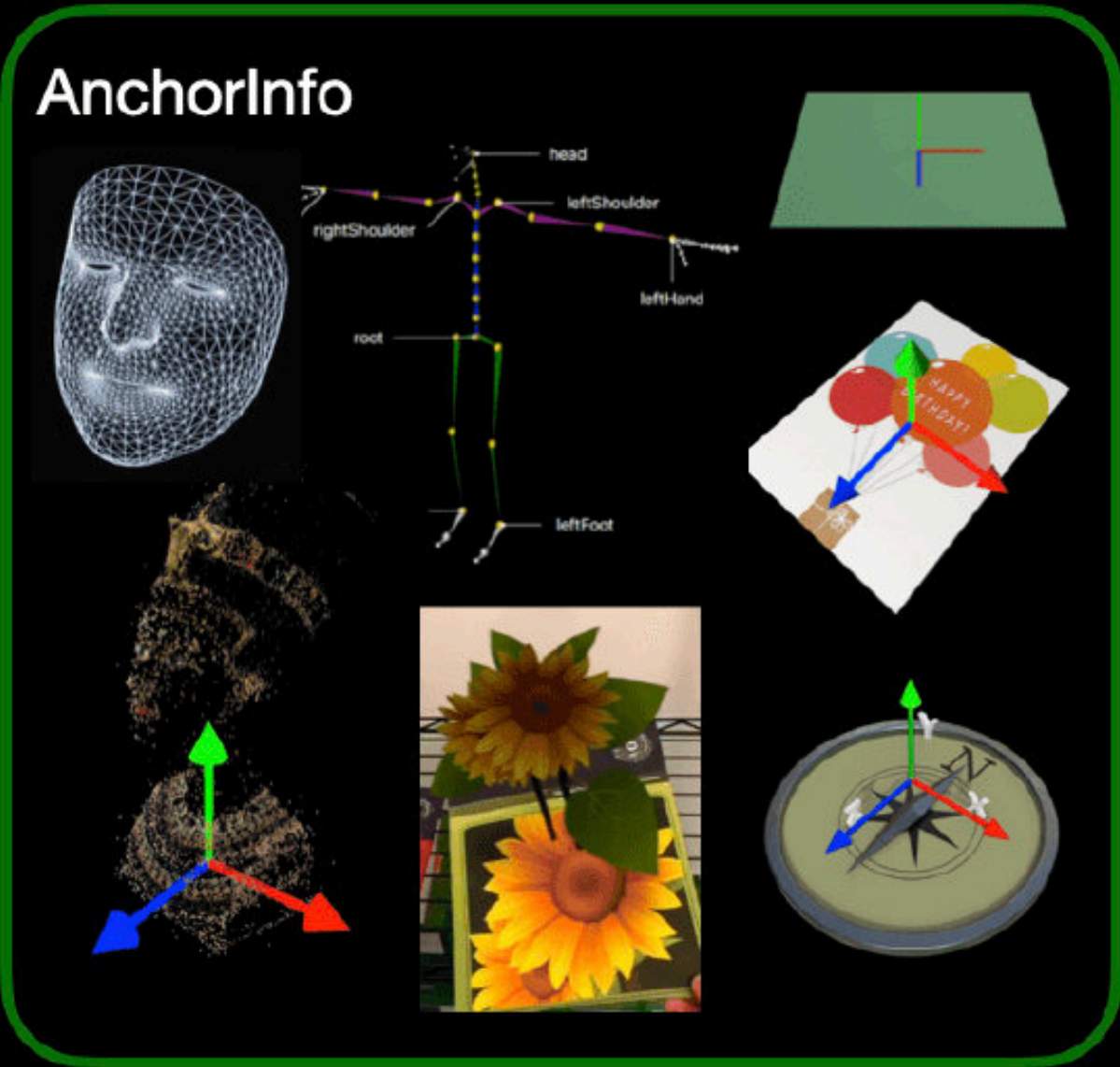


场景信息



ARKit - 理解

ARKit Features - Scene Understanding



识别跟踪信息

Anchor	跟踪类型	版本/系统要求	配置类
ARPlaneAnchor	平面	ARKit1 / iOS 11	ARWorldTrackingConfiguration
ARFaceAnchor	面部	ARKit1 / iOS 11	ARWorldTrackingConfiguration、ARFaceTrackingConfiguration
ARMeshAnchor	网格	ARKit3 / iOS 13.4	ARWorldTrackingConfiguration
ARParticipantAnchor	会话协作者	ARKit3 / iOS 13	ARWorldTrackingConfiguration
AREnvironmentProbeAnchor	环境探测	ARKit2 / iOS 12	ARWorldTrackingConfiguration
ARImageAnchor	图片	ARKit1 / iOS 11.3	ARWorldTrackingConfiguration、ARImageTrackingConfiguration
ARObjectAnchor	物体	ARKit2 / iOS 12	ARWorldTrackingConfiguration
ARBodyAnchor	人体	ARKit3 / iOS 13	ARBodyTrackingConfiguration
ARGeoAnchor	地理位置	ARKit4 / iOS 14	ARGeoTrackingConfiguration
ARAppClipCodeAnchor	App Clip Code	ARKit4 / iOS 14.3	ARWorldTrackingConfiguration

ARKit - 理解

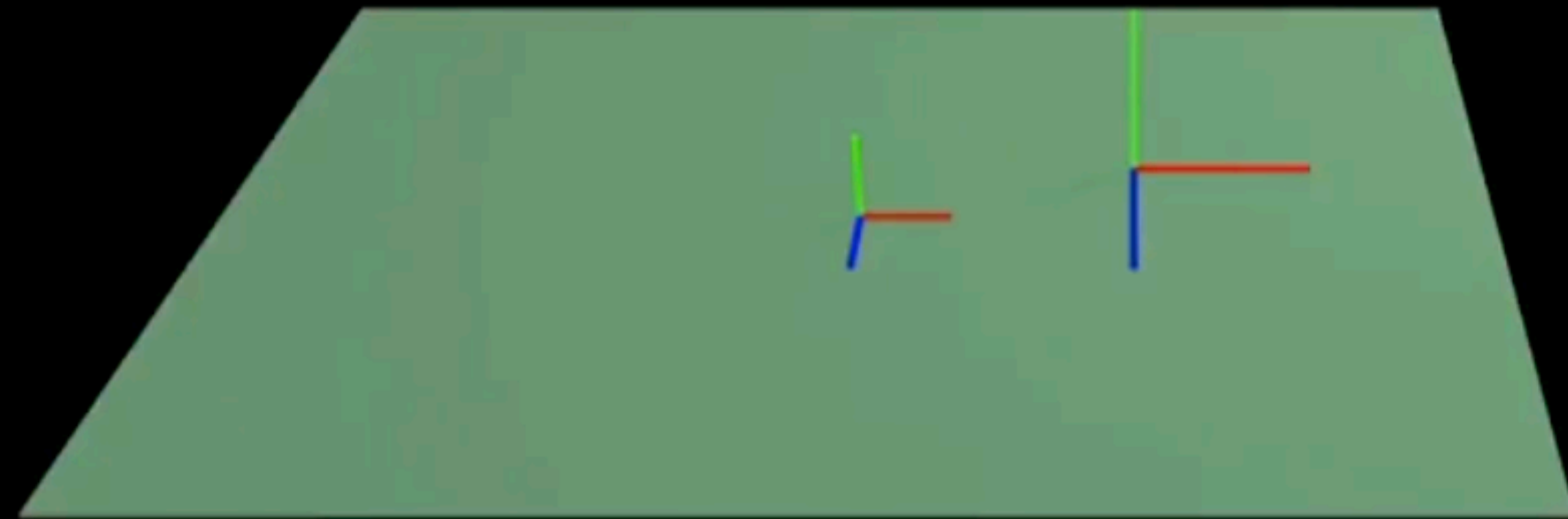
ARKit Features - Scene Understanding



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ARPlaneAnchor

- Transform
- Extent
- Center



Plane Detection

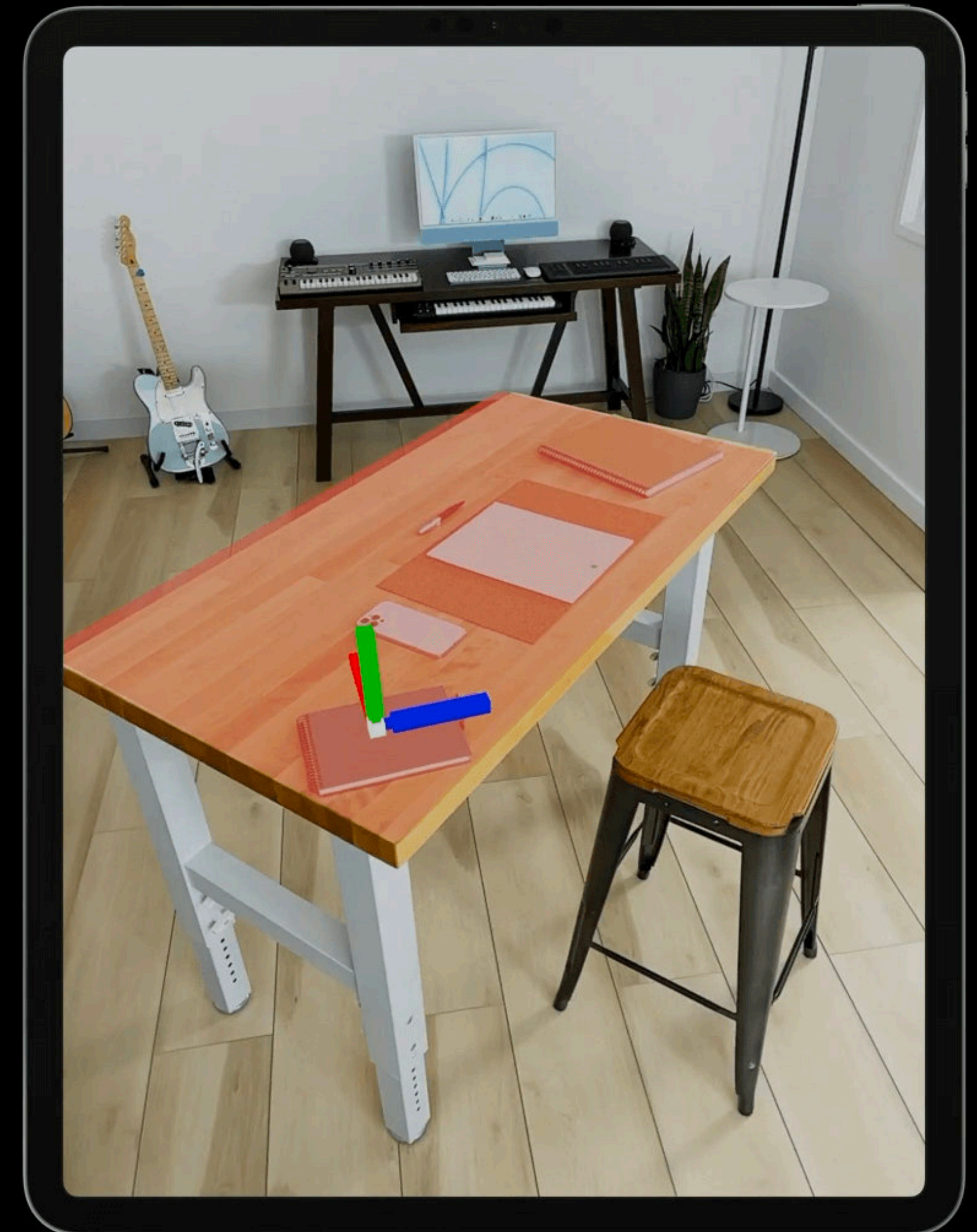
ARKit - 理解

ARKit Features - Scene Understanding

ARPlaneAnchor

ARKit 6

- ARPlaneExtent
 - rotationOnYAxis
 - width
 - height
- ARPlaneAnchor.center

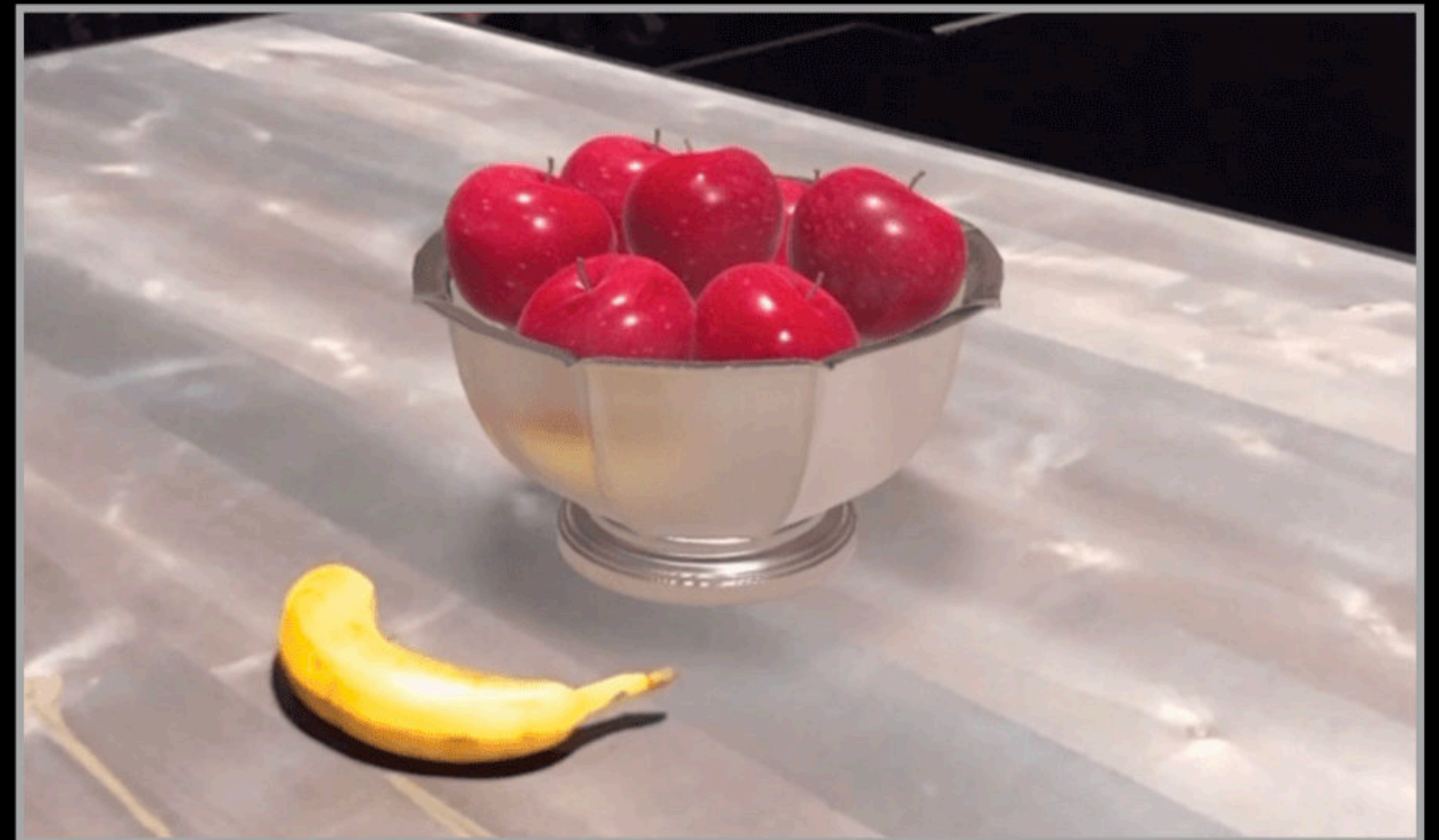


ARKit - 理解

ARKit Features - Scene Understanding

AREnvironmentProbeAnchor

- Light estimation (ARKit 1)



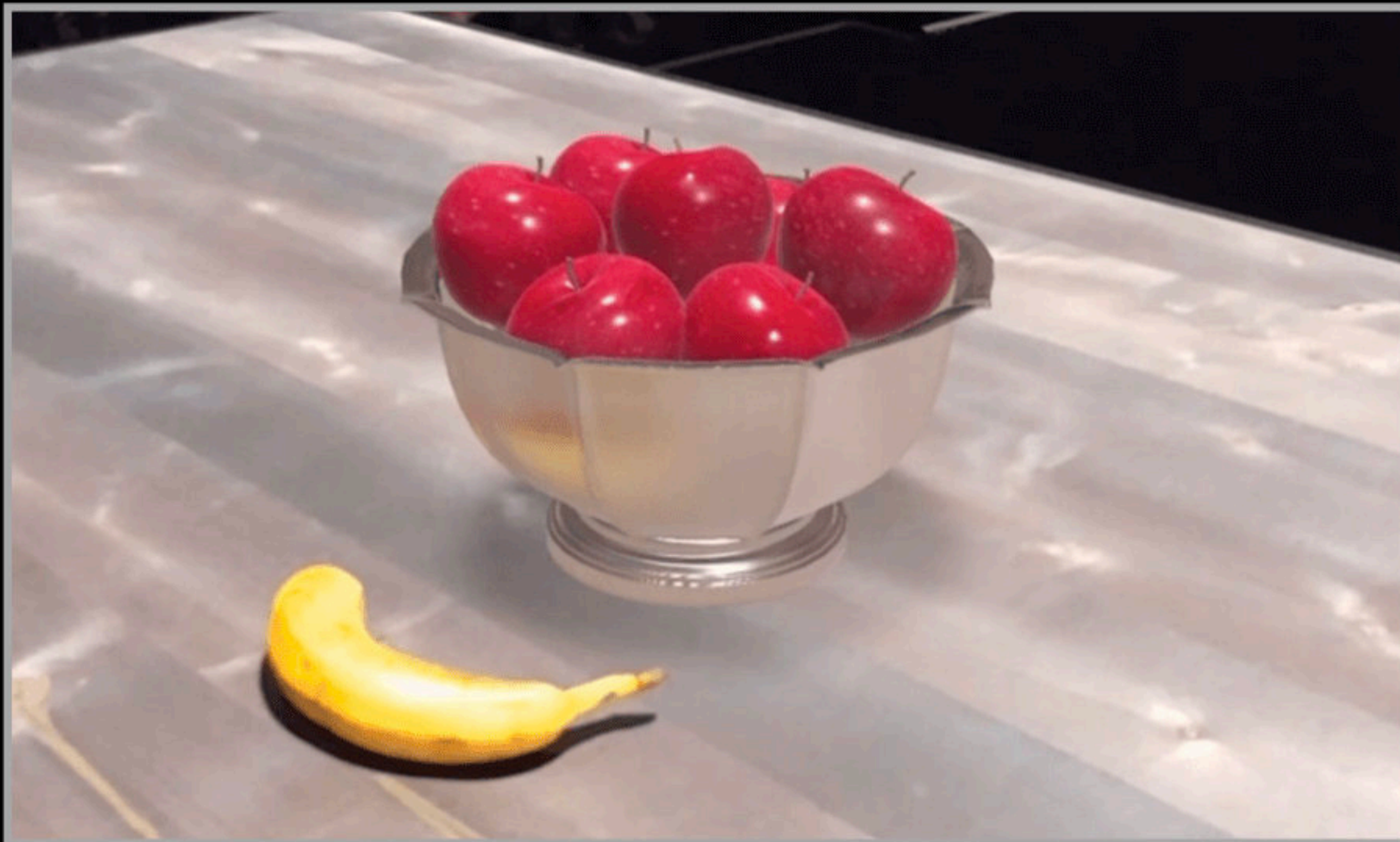
ARKit - 理解

ARKit Features - Scene Understanding



AREnvironmentProbeAnchor

- Environment Texturing (ARKit 2)

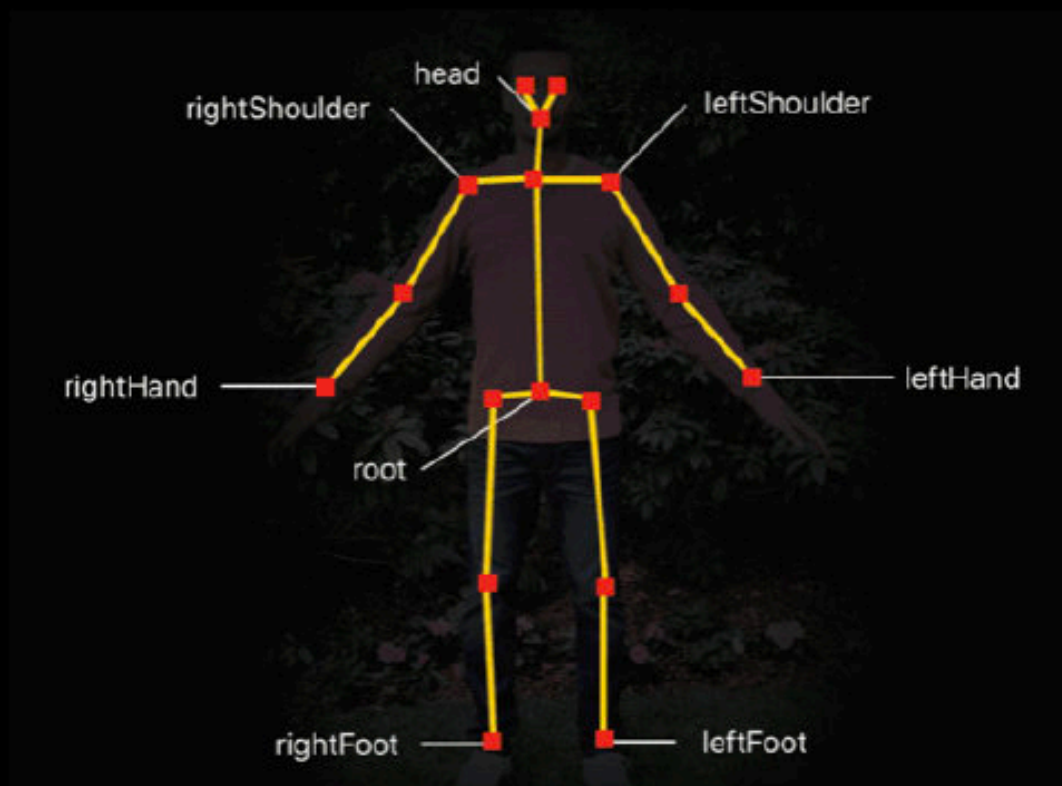


- 在场景中采集环境纹理，输出纹理贴图
- 交由 SceneKit、RealityKit、Metal 等渲染框架使用

ARKit - 理解

ARKit Features - Scene Understanding

BodyInfo



人体信息

```
// 人体 2D 骨骼信息
@available(iOS 13.0, *)
open var detectedBody: ARBody2D? { get }

// 人物遮挡相关 分割缓冲区
@available(iOS 13.0, *)
open var segmentationBuffer: CVPixelBuffer? { get }

// 估算的深度数据
@available(iOS 13.0, *)
open var estimatedDepthData: CVPixelBuffer? { get }
```

人体遮挡 People Occlusion

ARKit3

ARKit - 理解

ARKit Features - Scene Understanding

人体遮挡 People Occlusion



ARKit - 渲染

ARKit Features - Rendering



Rendering

Easy integration

AR views

Custom rendering

ARKit - 渲染

ARKit Features - Rendering



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ARKit

Processing

AVFoundation

CoreMotion

Rendering



ARKit - 渲染

ARKit Features - Rendering



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RealityKit

- 作为一个 3D 渲染引擎，和 ARKit 协同支撑开发
- 专为 AR 开发设计，降低了使用门槛
- 支持跨平台（iOS、iPadOS、macOS）
- 只支持 Swift 语言开发。



Rendering



Animation



Physics



Synchronization



ECS

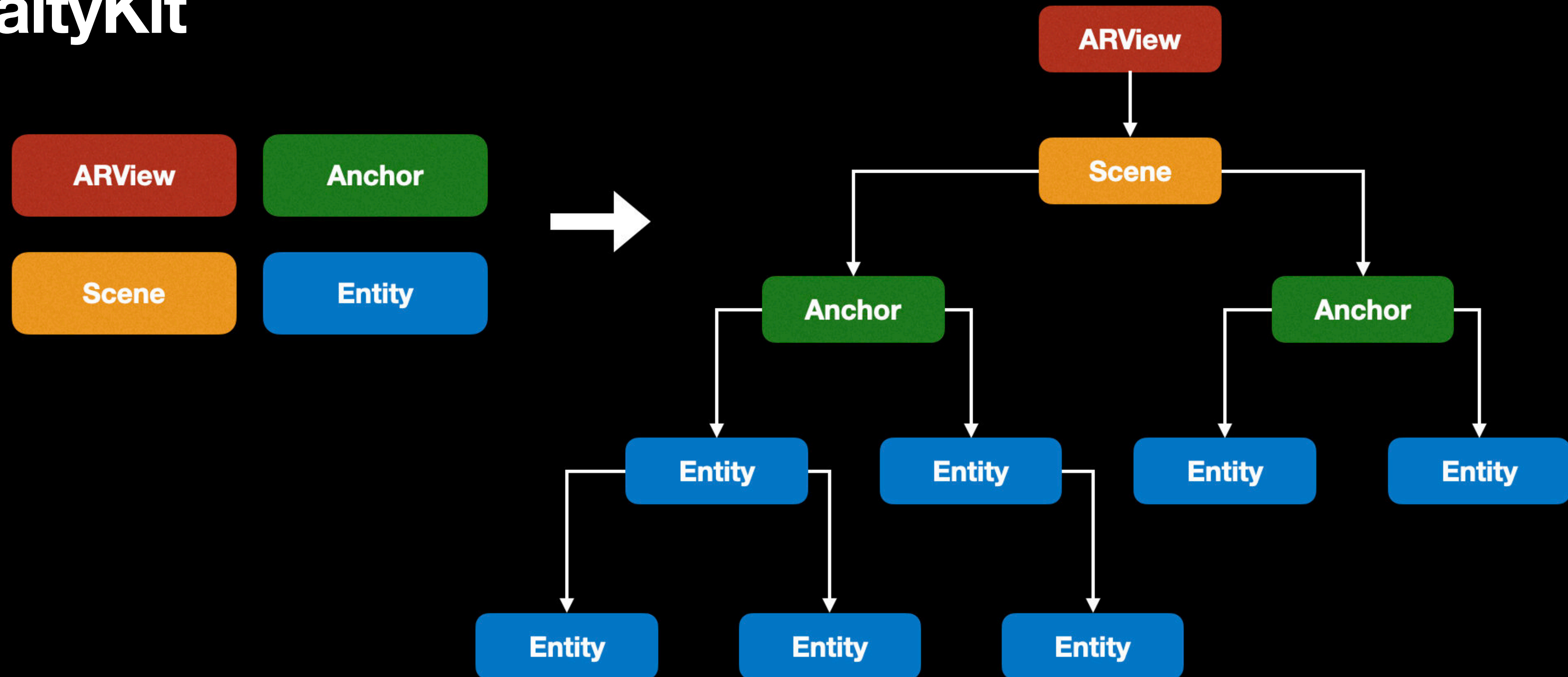


Audio

ARKit - 渲染

ARKit Features - Rendering

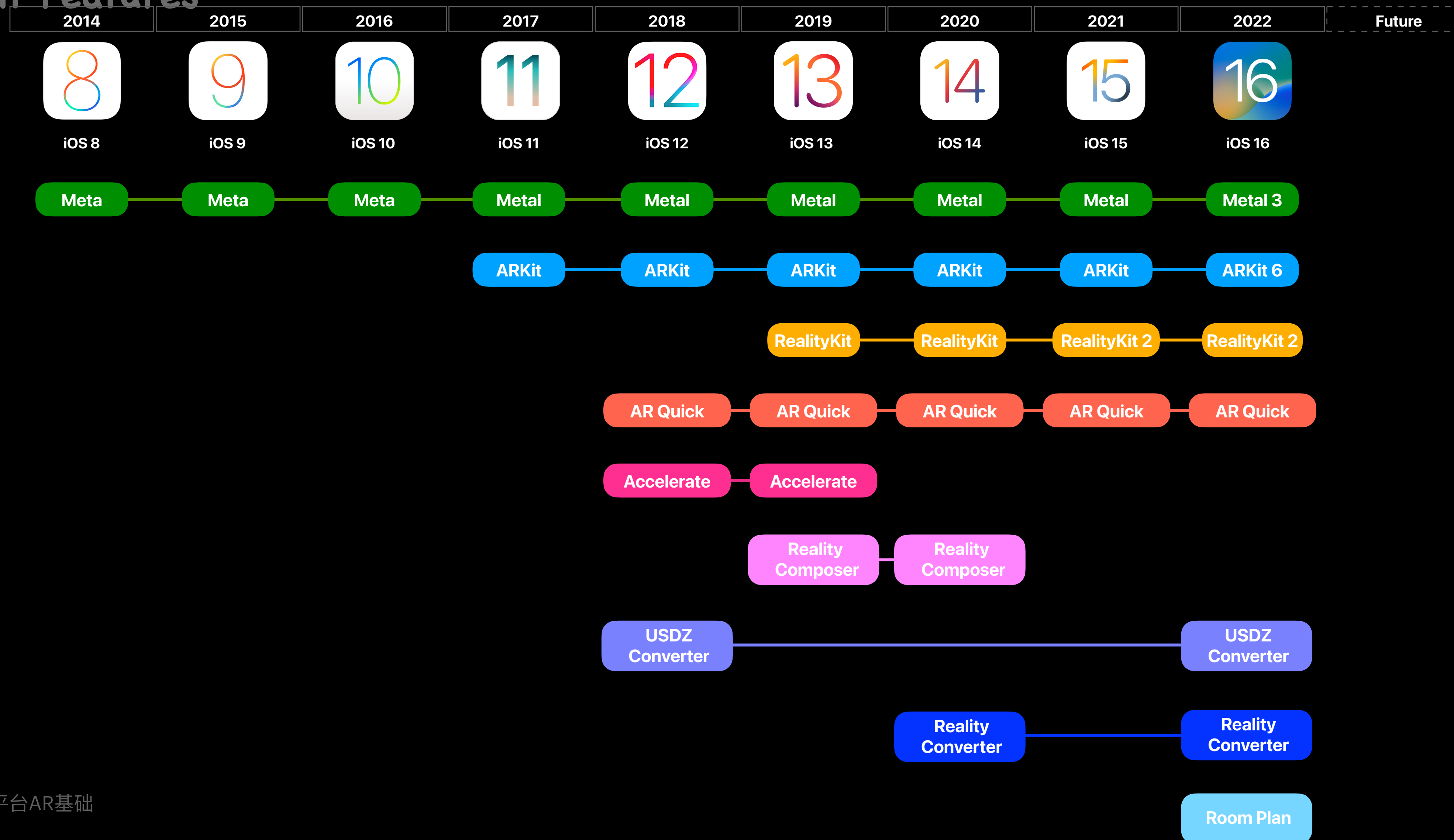
RealityKit



ARKit - 渲染 时间轴



ARKit Features



ARKit

ARKit History



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ARKit1-iOS11

- 跟踪
- 场景理解
- 渲染支持(SceneKit、SpriteKit、Metal、Unity、UE)
- 面部跟踪
- Metal 2.0

ARKit3-iOS13

- 会话协作
- 同时面部和世界跟踪
- Multiple-face 跟踪
- 人物遮挡
- Motion Capture支持
- Raycast 光线投射
- RealityKit 1.0
- Reality Composer

ARKit5-iOS15

- Location Anchor 增加城市
- iPad Pro面部跟踪视野增加
- Motion Capture优化
- AppClipAnchor支持
- RealityKit 2.0

- ARWorldMap
- 图片跟踪
- 物体检测、扫描
- 凝视跟踪(GazeTracking)
- 舌头检测
- 环境纹理
- 跟踪、理解优化

ARKit2-iOS12

- 面部跟踪支持A12及以上CPU
- Location Anchor支持
- 增加LiDAR传感器
- Depth Data
- RealityKit 1.5

ARKit4-iOS14

- 4K视频模式
- 相机增强
- Location Anchor增加城市
- Plane Anchor优化
- Motion Capture优化
- Metal3.0

ARKit6-iOS16

AR是什么

ARKit

构建AR应用

AR是什么

ARKit

构建AR应用

构建AR应用

Build AR Applications



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🤔 要构建优秀的AR应用，我们应该怎么做？

优秀AR应用示例

Good AR Applications



Lessons in Herstory

only available at  App store



WWF Forests



测距仪



IKEA Place

优秀AR应用示例

Good AR Applications

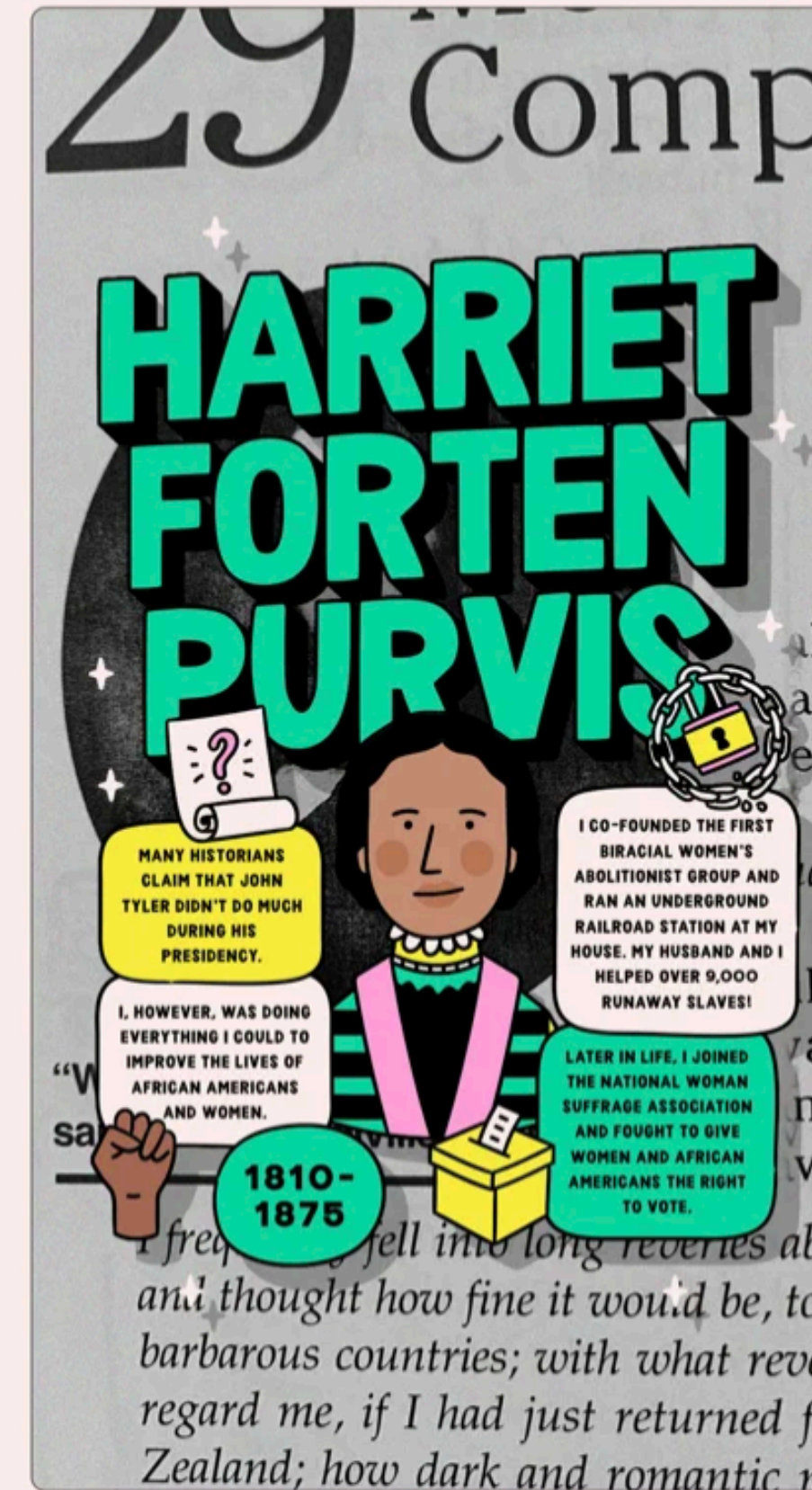


Lessons in Herstory

App store: <https://apps.apple.com/us/app/lessons-in-herstory/id1454032706>

iOS移动平台AR基础

Scan any portrait of a man to unlock
a related story about a woman.



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Browse through stories of amazing
women without a textbook.



优秀AR应用示例

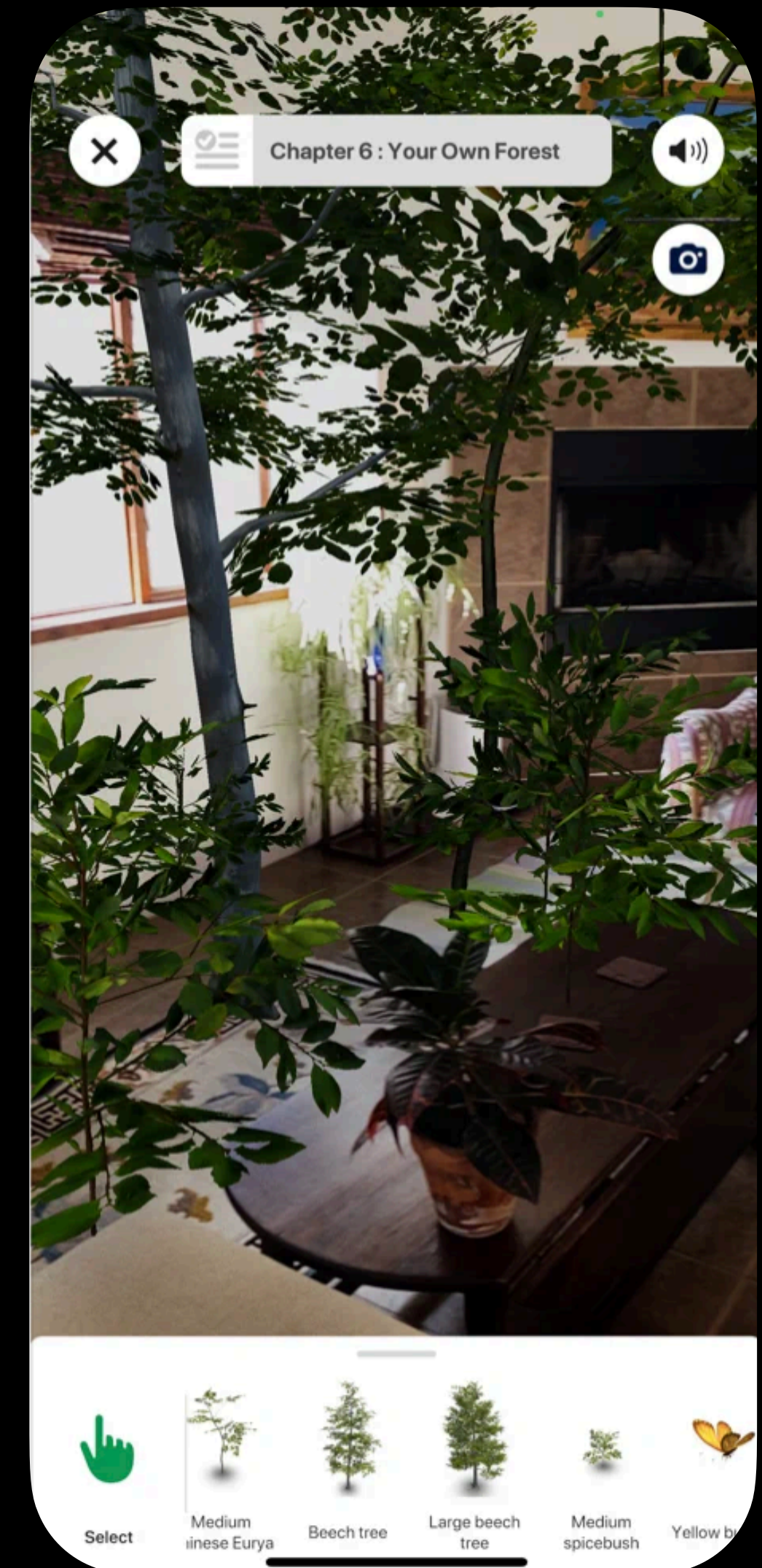
Good AR Applications



WWF Forests

App store: <https://apps.apple.com/us/app/wwf-forests/id1518039408>

iOS移动平台AR基础



优秀AR应用示例

Good AR Applications



测距仪



App store: <https://apps.apple.com/cn/app/%E6%B5%8B%E8%B7%9D%E4%BB%AA/id1383426740>

优秀AR应用示例

Good AR Applications



IKEA

Try true-to-scale models
of IKEA furniture



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Experiences that embrace
the world around you



App store: <https://apps.apple.com/gb/app/ikea-place/id1279244498>

好的AR产品必须做到什么？

What makes a great AR app



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目标

内容

体验

好的AR产品必须做到什么？

What makes a great AR app



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目标

什么场景时应考虑使用增强现实技术？

增强现实技术将虚拟物体与现实世界融合在一起，使人身临其境，带给人们魔法一般的奇妙体验

- 以最直观的方式去解决一些事情
- 以最快的方式影响我们周遭的环境
- 以最简单的方式创建可视化虚拟模型体验

好的AR产品必须做到什么？

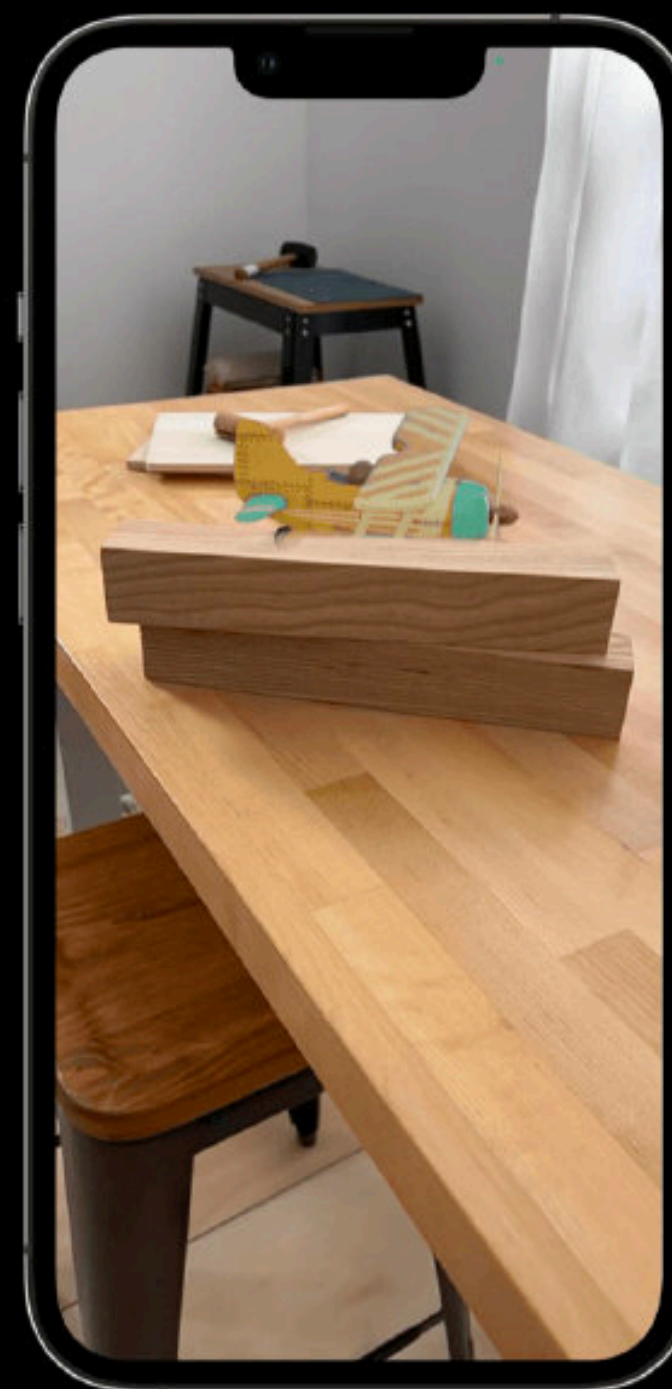
What makes a great AR app



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内容

- AR 内容是具有 3D 空间性的
- AR 需要与现实世界紧密结合



好的AR产品必须做到什么？

What makes a great AR app

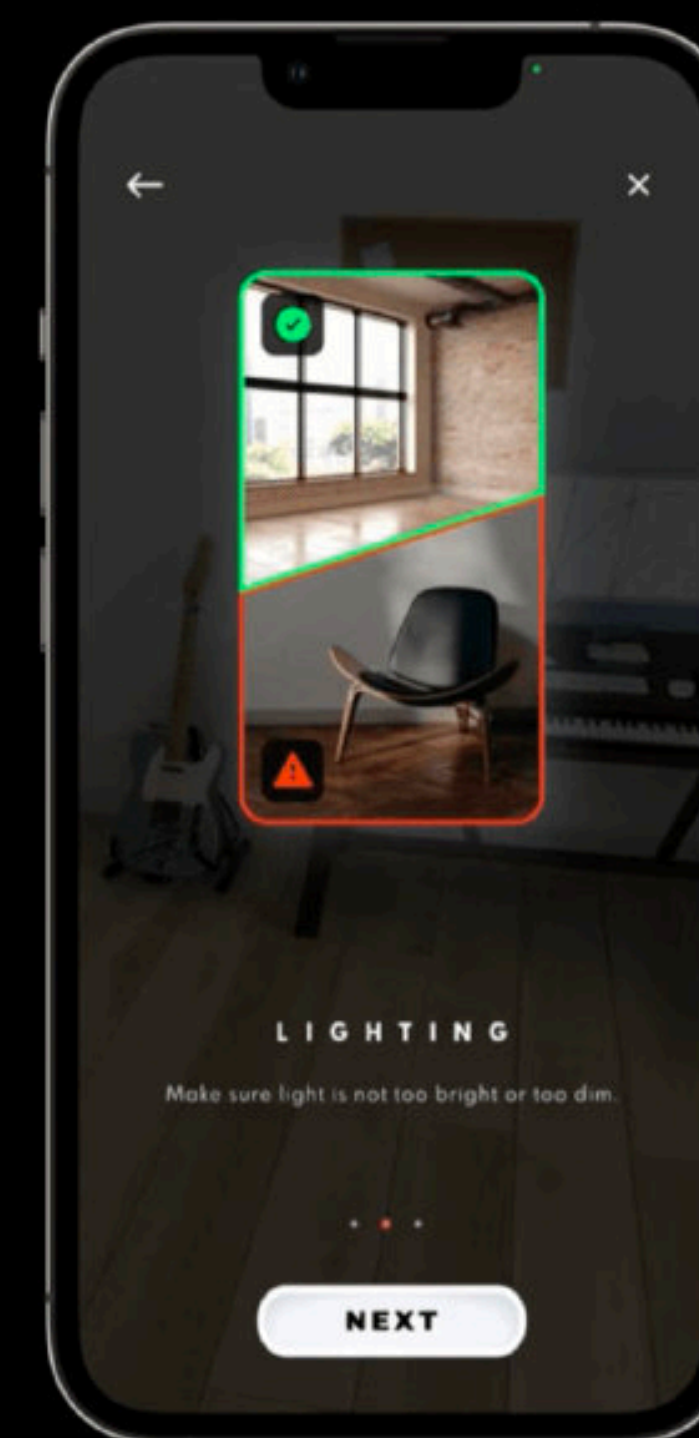
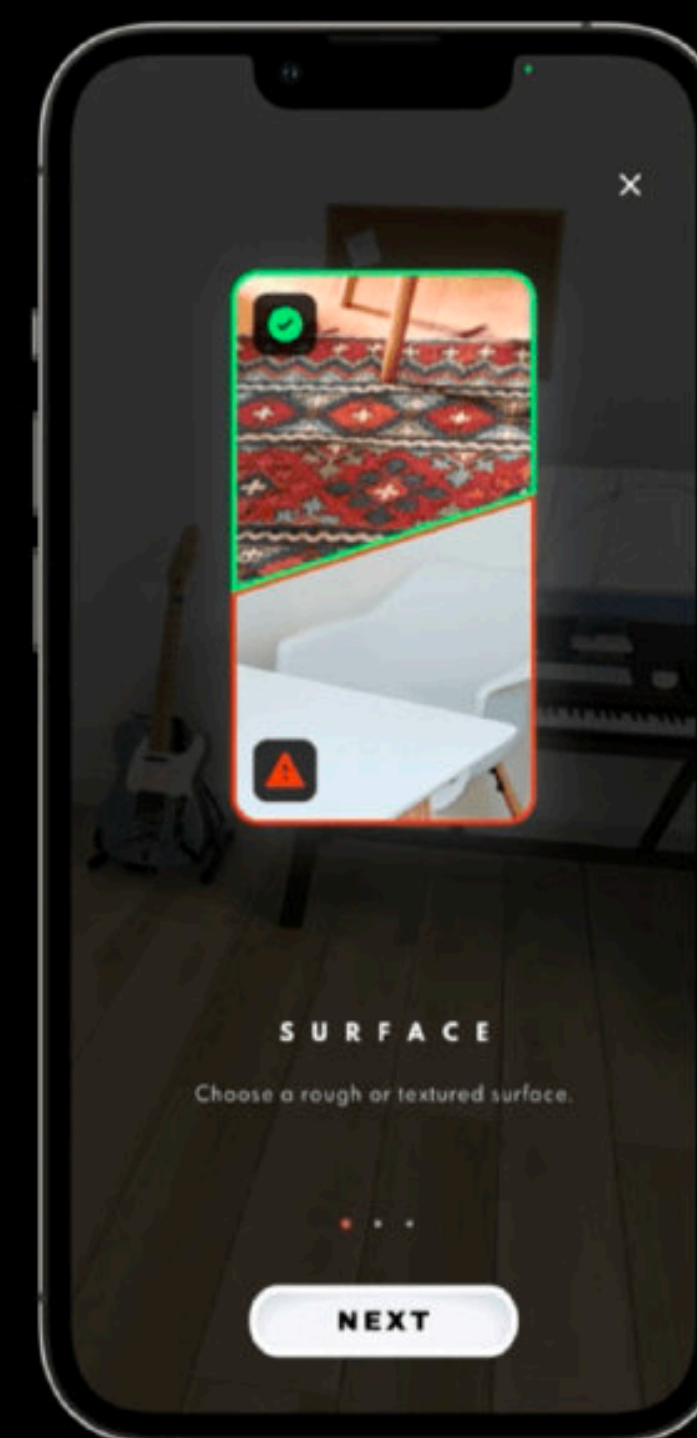
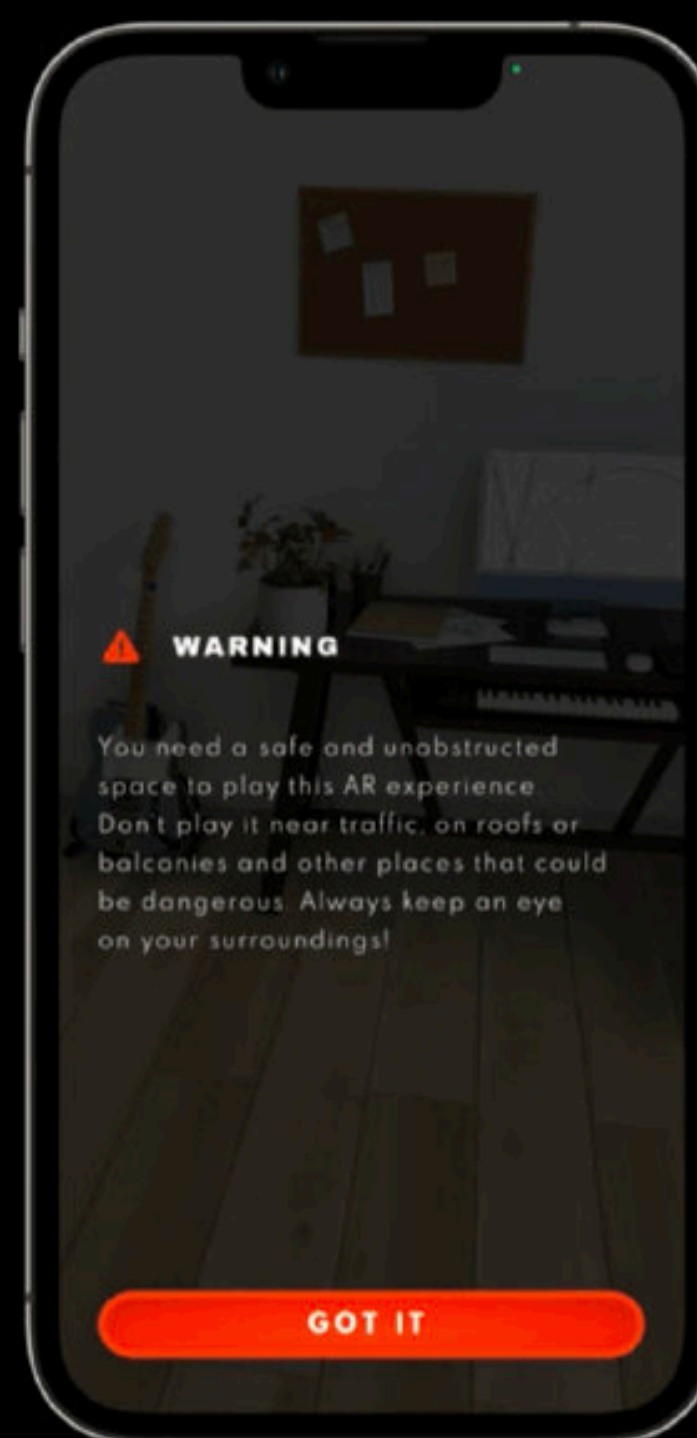


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体验

AR 应用应提供必要的用户引导

- 用户所处的环境不一定理想



好的AR产品必须做到什么？

What makes a great AR app



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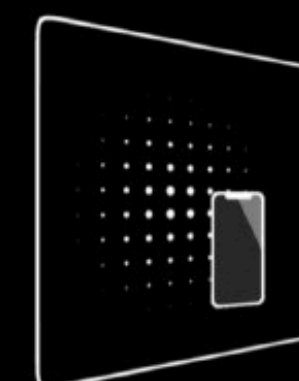
体验

AR 应用应提供必要的用户引导

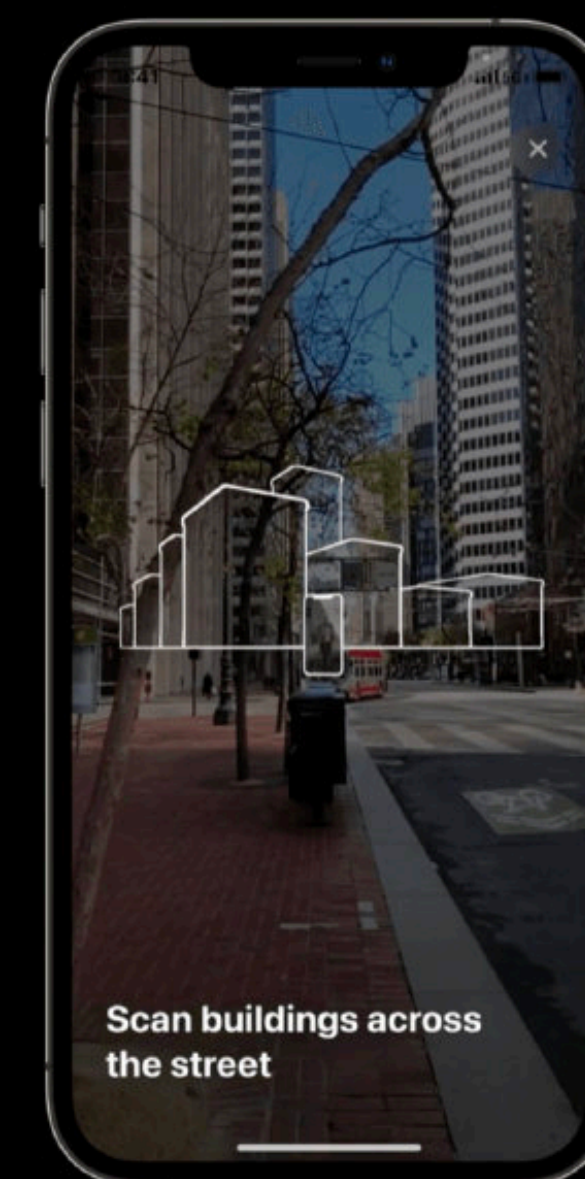
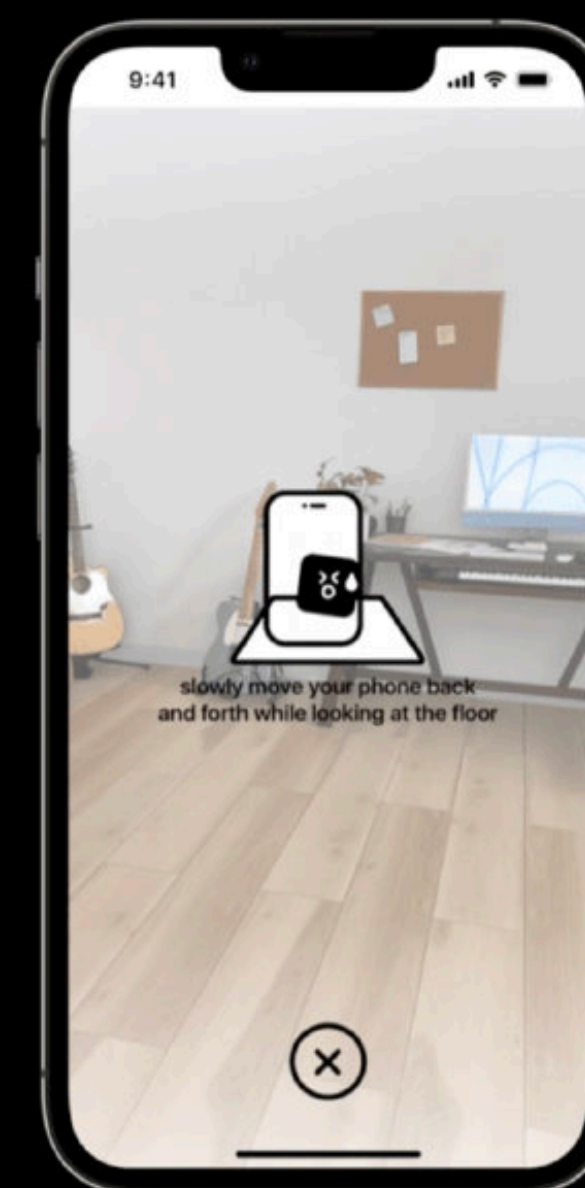
- 用户所处的环境不一定理想
- 新手友好



移动iPhone开始



移动iPhone开始



好的AR产品必须做到什么？

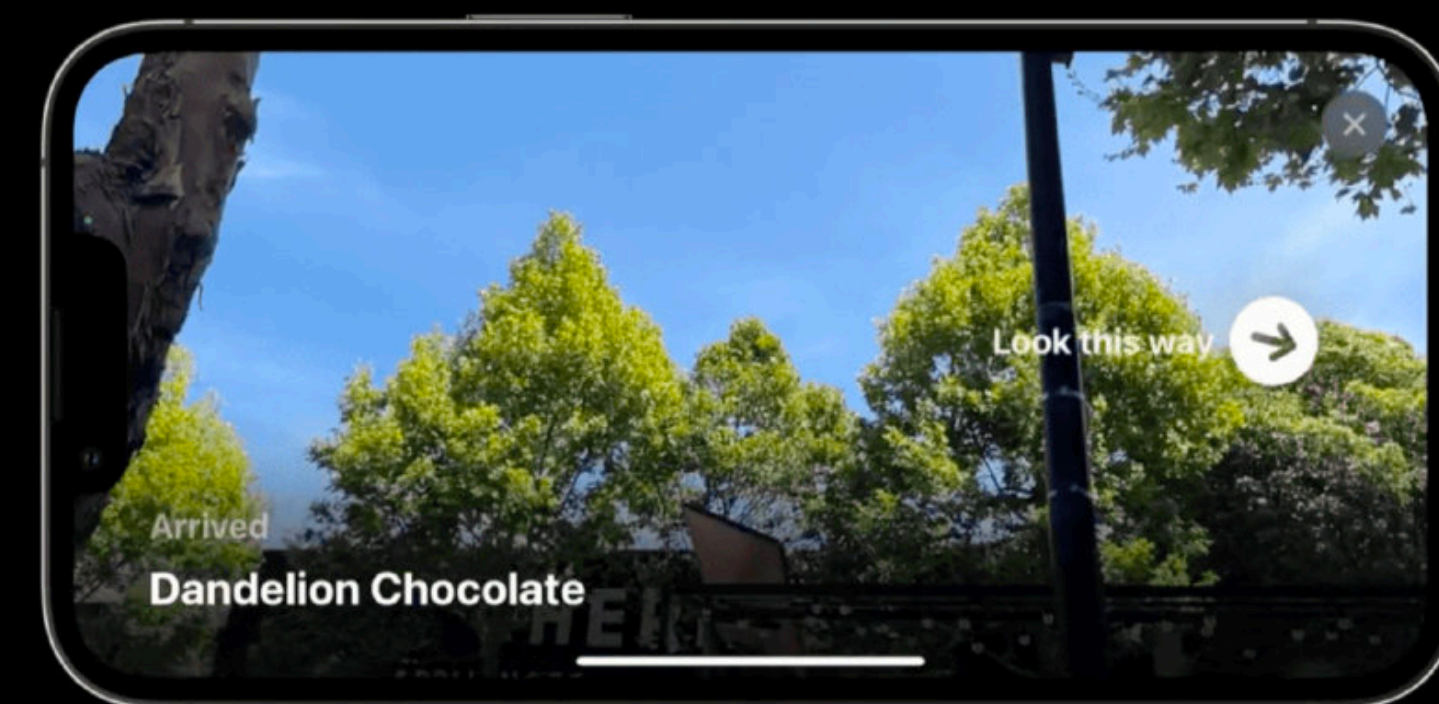
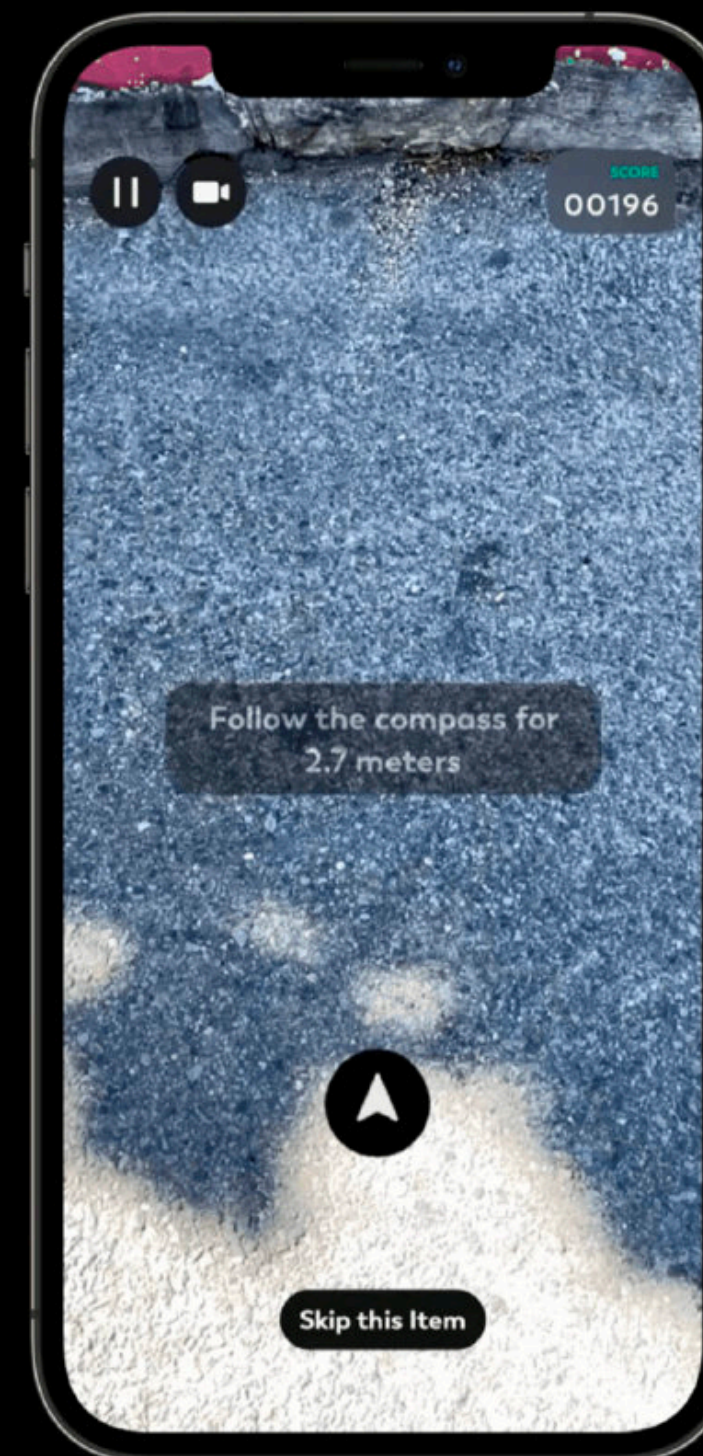
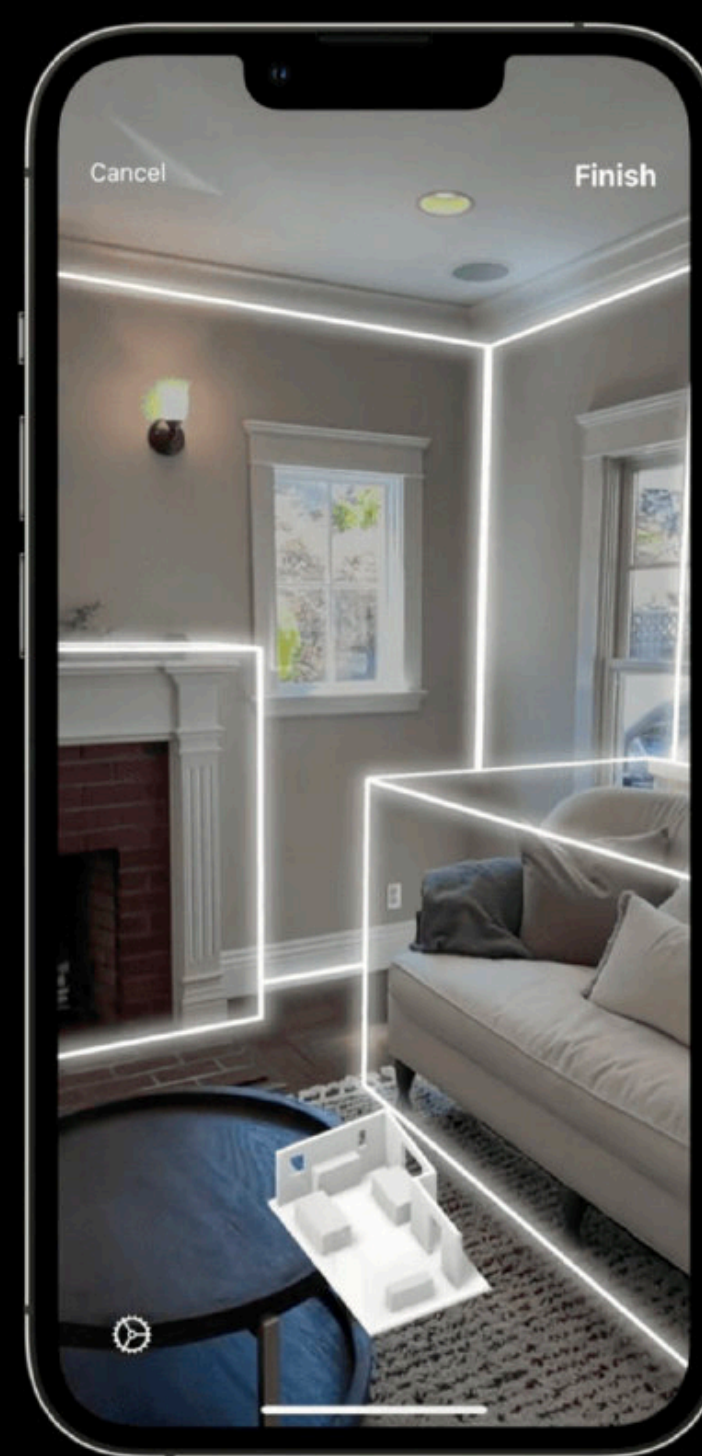
What makes a great AR app



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AR 应用应引导用户移动

体验



Any Questions?