The State of Open Source XR

Monado and beyond

Christoph Haag

christoph.haag@collabora.com

01/02/2026

FOSDEM '26

COLLABORA

Outline

- VR Hardware and Tracking Systems

- Software

    - 6DoF Tracking

    - General Hardware Support (USB Protocol, Lens Distortion etc.)

- The State of Monado

- The Open Source XR Ecosystem

- **VR Hardware and Tracking Systems**

- 1968: Ivan Sutherland

- ...

- Affordable hardware super low resolution, laggy

- Then 2012: Oculus Rift DK1

  - Small affordable smartphone displays

  - Low latency

  - Low persistence

VR Hardware: Oculus Rift DK1

- Only IMU (Inertial Measurement Unit)

- Tracks Rotation & Acceleration

    - Knows gravity = down

    - No position

    - Direction drift

By Sebastian Stabinger - Own work
CC BY 3.0
https://commons.wikimedia.org/w/index.php?curid=30068952

Tracking Systems

- 3 major positional tracking systems

  - LED ("Constellation")

  - Lighthouse

  - SLAM

Tracking Systems

LED ("Constellation")

- Oculus Rift DK2

  - Known pattern of LEDs on Headset

  - USB camera (webcam), usually with InfraRed filter

  - Computer Vision: Match LED pattern to 3D pose

  - Camera calibration for accurate distances

By ATs Kurvet - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35919328

By Ats Kurvet - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35919779

Tracking Systems

Lighthouse

- HTC Vive

    - Laser sweeps from completely independent base stations

    - Sensors on headset register exact time when hit by sweep

    - "Computer Vision": Match timestamps to 3D pose

    - https://www.youtube.com/watch?v=75ZytcYANTA

By Solomon203 - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=75134551

Tracking Systems

By International Railway Summit - ShowCase Innovation Gallery, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=78373959

SLAM

- Windows Mixed Reality
    - "Simultaneous Localization and Mapping"
    - Cameras built into headset, no fixed external reference
    - Computer Vision: Automatically determine suitable "features"
    - Computer Vision: Re-recognize features & Estimate camera position

Tracking Systems

LED ("Constellation")

- Oculus Rift DK2

- OSVR HDK

- Oculus Rift CV1

- Playstation VR

Lighthouse

- HTC Vive

- Valve Index

- HTC Vive Cosmos Elite

- Pimax 5k, 8k

- Shiftall MeganeX

- Bigscreen Beyond

- Somnium VR1

SLAM

- Windows Mixed Reality

- Oculus Rift S

- HTC Vive Cosmos (on-device)

- Pimax Crystal Light

- PSVR2 (on-device)

But: LED tracking for controllers

LED ("Constellation")

- Windows Mixed Reality controllers

SLAM

- Windows Mixed Reality headset

By International Railway Summit - ShowCase Innovation Gallery, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=78373959

Standalone headsets?

By gov_mcti - https://www.flickr.com/photos/129765943@N04/54121230833/, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=155021950

- Typically

  - bootloader locked

- But:

- Lynx R1, supports mainline Linux porting effort

  - https://wiki.postmarketos.org/wiki/Lynx_R1_(lynx-r1)

  - Official ROM Android based, Qualcomm Spaces based OpenXR Runtime

- Steam Frame ?!?!?!?

Software: OpenHMD

- From 2013 to ca. 2021

- Now mostly unmaintained

FOSDEM 2019 Report

THEONLYJOEY | FEBRUARY 9, 2019

Software: OSVR

- HDK headset by Razer

- SDK by Sensics

    - Open source HDK (2) driver & camera tracking

- Sensics ceased operations in 2019

- OSVR mostly unmaintained

Software: Monado

- OpenGL & Vulkan have mesa

- We wanted OpenXR to have monado

    - Loosely based on mesa design

Software: Monado

- This list is incomplete. You can help by expanding it

```
∨ monado
  ∨ src
    > external
    ∨ xrt
      > auxiliary
      > compositor
      ∨ drivers
        > android
        > arduino
        > blubur_s1
        > daydream
        > depthai
        > euroc
        > hdk
        > ht
        > ht_ctrl_emu
        > hydra
        > illixr
        > multi_wrapper
        > north_star
        > ohmd
        > opengloves
        > psmv
        > pssense
        > psvr
        > qwerty
        > realsense
        > remote
        > rift
        > rift_s
        > rokid
        > sample
        > simula
        > simulated
        > solarxr
        > steamvr_lh
        > survive
        > twrap
        > ultraleap_v2
        > ultraleap_v5
        > v4l2
        > vf
        > vive
        > vp2
        > wmr
        > xreal_air
```

Software: Monado

- LED Tracking

  - PSVR, PS Move

    - "simple" tracking framework, shipped by IVRy, but no further development

  - Oculus Rift DK2, CV1, S controllers, WMR controllers

    - Started by Thaytan in OpenHMD

    - Various out of tree branches by various contributors

- Lighthouse

  - Libsurvive: "Almost usable", currently minimally maintained by Collabora

  - steamvr_lh: wrapper for **closed source** lighthouse.so

- SLAM

  - Basalt is CPU heavy, tracking quality is not reaching commercial systems yet

  - New SLAM frameworks keep coming out, some open source

Software: Monado

- Demo Videos

Software: Monado

- Hand Tracking

  - Stereo Cameras

  - onnx model trained on open & synthetic data

Software: Monado

- Direct Mode on Windows

  - Public API exists, does not support most headsets

    - Special EDID entry required, not fake-able by Windows Home/Pro

    - Needs research whether it can be made to work

  - Most headsets supported via NDA APIs from Nvidia, Intel, AMD

    - Wrapping existing libraries like OSVR-RenderManager legally possible?

Software: Monado

- Reprojection

  - 3DOF Timewarp: Correct for head rotation

    - Available now in Monado

  - 6DOF Reprojection: Correct for head movement (best with app submitted depth)

    - Old branch integrating OpenWarp exists

  - "Spacewarp", "Motion Smoothing": Enhance reprojection with motion vectors, either predicted or app submitted

    - Keeps in-game object motion from stopping/stuttering on missing frames

Software: Monado

- Proper standalone port
  - (GNU/)Linux
    - "Just" need hardware drivers
    - Simula VR One (Monado driver actually mainline)
    - Lynx R1?
    - SoC (rk3588?)
  - Android
    - Currently "Google Cardboard" 3DOF
      - Supports even Google Cardboard QR
    - Need android SLAM/Controller Tracking/Hand Tracking
    - Android Compositor improvements
    - Lynx R1?
    - SoC (rk3588?)

Software: Monado

- Demo

By Evan-Amos - Own work, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=45580283

Software: Monado

- VERY good idea to talk to us and/or community before starting

- Create gitlab issue on https://gitlab.freedesktop.org/monado/monado

- Matrix / Discord Bridged

  - https://discord.com/invite/um7xRqq2fq

  - https://matrix.to/#/#monado:matrix.org

- IRC #monado on OFTC

  - https://webchat.oftc.net/?channels=monado

Software: Monado

- The future: MR, AR and perception

- Detect planes, objects, ...

- Environment depth estimation

- Construct Mesh from environment

- Semantic labeling of objects

- Luckily: AI commodization

- More Multi App

Open Source XR Ecosystem: Desktop

- xrdesktop
    - Mirror individual windows from kwin/gnome-shell into XR
    - Standalone XR-only wayland compositor
    - Initially funded by Valve, currently not really active
- WayVR (previously wlx-overlay-s)
    - Mirror monitors into XR
- Stardust XR
    - Ambitious, comprehensive display server
- Simula VR?

Open Source XR Ecosystem: Tools

- Development
    - Godot
    - LÖVR
    - osgXR
    - StereoKit
    - Bevy
- ParaView
- Blender
- FreeCad

Open Source XR Ecosystem: Web

- ~~Firefox~~
    - OpenVR only, Windows only. WebXR not complete, no current XR effort

- ~~Chrome/Chromium~~
    - OpenXR, but appears not interested in Linux support
    - May be changing due to Steam Frame

- WebKit
    - Igalia working on it, partially working already

- Servo?
    - OpenXR, but no WebXR on Linux yet

- Android based with Lepton?
    - Wolvic, Android Chromium, …

Open Source XR Ecosystem: Web

- Demo: Webkit

Open Source XR Ecosystem: Social

- Overte

- WIP

    - V-Sekai

    - UNAVI

    - Rhubarb

    - BarkVR

- Basis

    - Unity Engine

Open Source XR Ecosystem: Games

- OpenMW https://gitlab.com/madsbuvi/openmw

- The Dark Mod VR (inactive) https://github.com/fholger/thedarkmodvr

- FlightGear https://wiki.flightgear.org/Virtual_Reality

- BeepSaber (Godot) https://codeberg.org/LibreVR/BeepSaber/

- FreeSpace 2 https://wiki.hard-light.net/index.php/Virtual_Reality

- Godot XR Game Jam entries typically publish source, though limited in scope
    - https://itch.io/search?q=Godot%20XR&type=jams

Open Source XR Ecosystem: Lepton?

- Valve developing Lepton (Waydroid based) for Steam Frame

- Open Source OpenXR apps from android based VR headsets

  - Android XR

  - Meta Quest

  - Pico

  - Lynx

- Team Beef Ports https://github.com/Team-Beef-Studios

  - Often based on open source engine with linux support

Thank you!

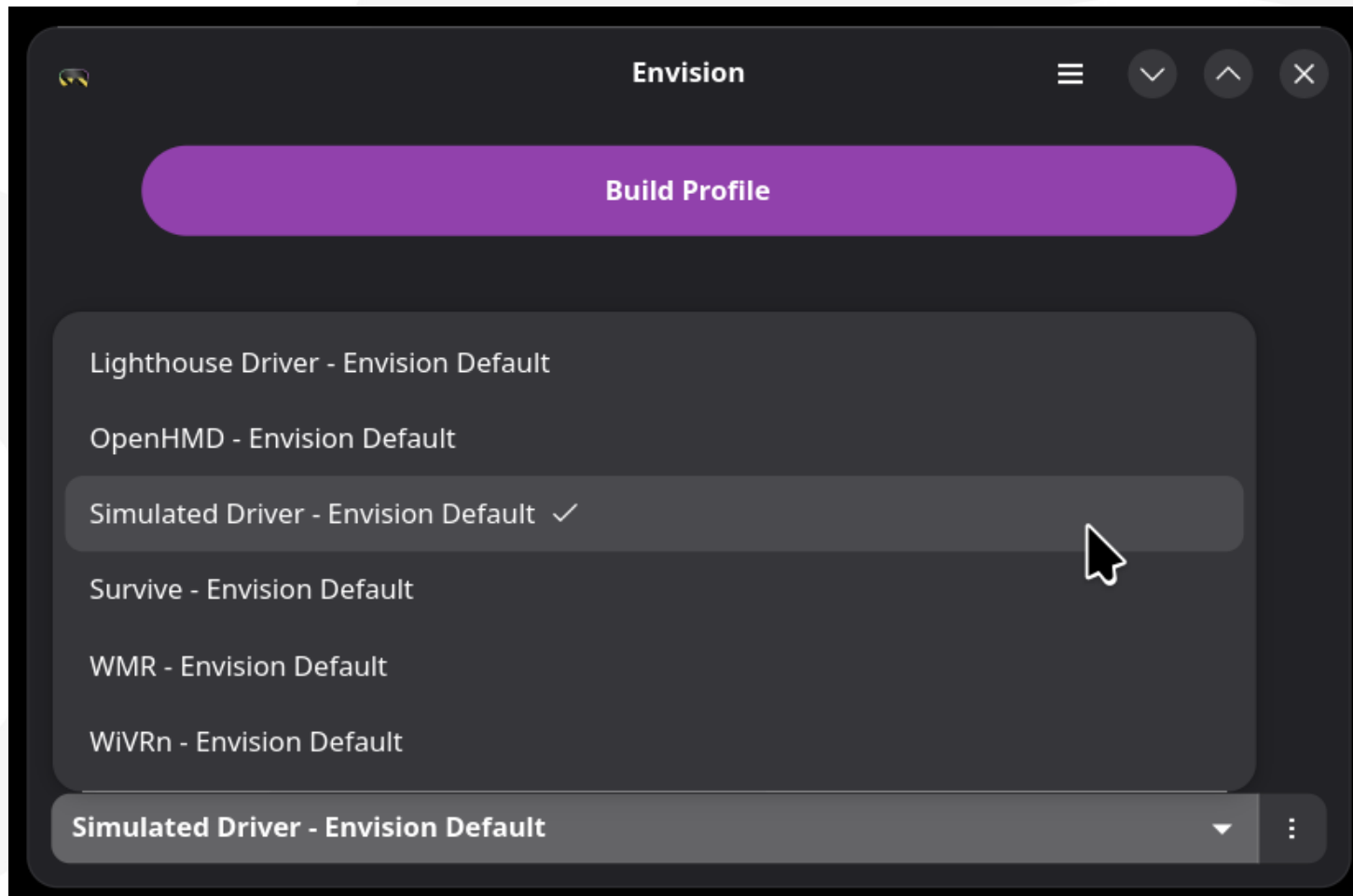**We are hiring - col.la/careers**

Extra Slides

Open Source XR Ecosystem: Utilities

- WayVR (again)

- Motoc
    - Sync (and keep synced) different tracking systems (Vive Tracker & Quest 3)

- xrBinder

    - Rebind inputs

- Keep an eye on

    - https://lvra.gitlab.io/docs/fossvr/

    - https://gitlab.com/foss-vr/foss-vr

Open Source XR Ecosystem: Envision

- GUI helper for compiling Monado configurations

Open Source XR Ecosystem: Other

- Gaia Sky https://gaiasky.space/

- VR Media Player (Flat, 180/360, Stereo) https://github.com/silphendio/vr-media-player/

AR Glasses?

- AR towards glasses form factor

- Much lower field of view

- Low End 3DoF or even no tracking

  - High end has cameras for SLAM

By RuinDig/Yuki Uchida - Own work, CC BY 4.0,
https://commons.wikimedia.org/w/index.php?curid=153975524

By Xuthoria - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=179047007

Software: Monado

- UI

  - XRT_DEBUG_GUI

    - imgui based, not very pretty, lots of internals for drivers

  - libmonado

    - Wayvr, motoc,

  - Desktop UI

    - Tray icon

    - Quit button

    - Configuration / Settings

    - Room Setup (lovr-playspace)

  - In-VR UI?

    - Process management (autorunner functionality)

Software: Monado

- Settings and Configuration

  - Currently lots of env vars

    - Move more to ~/.config/monado/config_v0.json

    - Persistent Configuration / Settings UI

Software: Monado

- Drivers

- Companies and community projects keep releasing new hardware

  - Vive Cosmos

  - Vive Ultimate Trackers

  - Pimax Crystal

  - Somnium VR1

  - MeganeX Superlight

  - FluxPose

  - SlimeVR (WIP)

  - Project Babble

  - ETVR

- Take docs or wireshark USB capture and start a driver

Software: Electric Maple

- Streaming Solution based on Monado

- Server: Linux, Windows (WIP)

  - OpenXR runtime sends rendered images over network & receives input over network

- Client: Android, Linux (WIP)

  - OpenXR application that delegates rendering to the display and getting input to a native OpenXR runtime

  - Native OpenXR runtime can be proprietary, or Monado on Android or Linux

- WebRTC, gstreamer