

Visual Display Ontology

VDO

Semantic Reasoning for Adaptive Display Systems

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Why Do Displays Need Intelligence?

- Displays today are static systems operating in dynamic, context-rich environments.

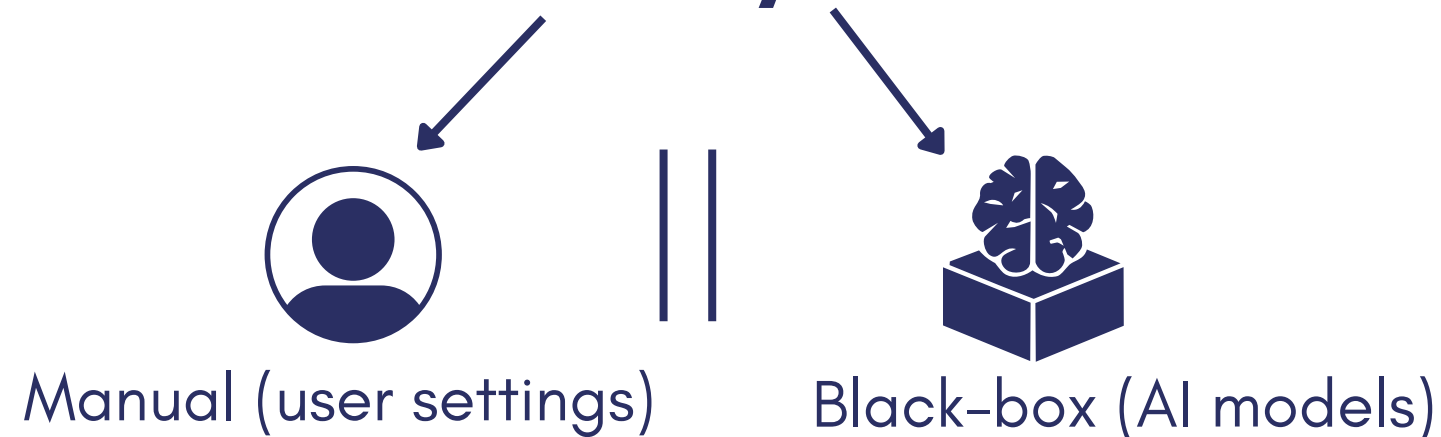
 - A monitor behaves **identically** whether the user is **fatigued** or **fresh**
 - An **OLED** screen shows **static content** for hours with **no burn-in awareness**
 - A **VR** headset runs at **low refresh rates** with **no motion sickness warning**

No system connects device capabilities to user wellbeing or hardware health

There is no unified, structured model that links:

- Device physical structure (what it is made of)
- Underlying technology (how it produces images)
- Component-level metrics (degradation, fatigue)
- Human biological effects (eye strain, motion sickness)
- Adaptive behavioral responses (mode switching, recommendations)

Current systems:



Missing:

An explainable semantic reasoning layer

An ontology-driven reasoning system for visual display adaptation.

- **What it does:**

- Models display devices as a **structured, layered knowledge graph**
- Encodes domain rules as **logical axioms**
- Lets a formal reasoner **automatically infer risks** and **required actions**
- Connects physical properties all the way to human-facing decisions

Existing approaches:

Approach	How it works	Limitation
Spec-based (datasheets)	Describes hardware properties	Descriptive only – no reasoning
UX settings (manual)	User configures preferences	No semantic model, no automation
AI models	Neural networks optimize display	Black-box – not explainable

The gap:

No existing system combines semantic structure, explainable logic, and automatic adaptation in a single model.

A multi-layer OWL 2 DL ontology for visual display systems with inference-driven intelligence.

- **Property chains:** automatic propagation of knowledge across layers
(**device** → **technology** → **component** → **material**)
- **Datatype reasoning:** numeric thresholds (latency, refresh rate, pixel fatigue percentage) **trigger** semantic class membership automatically
- **Context-aware adaptation:** user health states and hardware degradation states drive recommended display mode changes

EVOLUTION

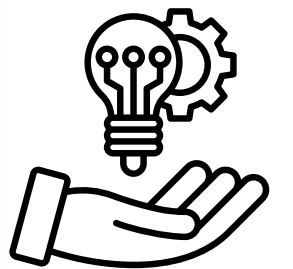
We take existing hardware knowledge and formalize it into machine-readable logic that enables automatic inference.

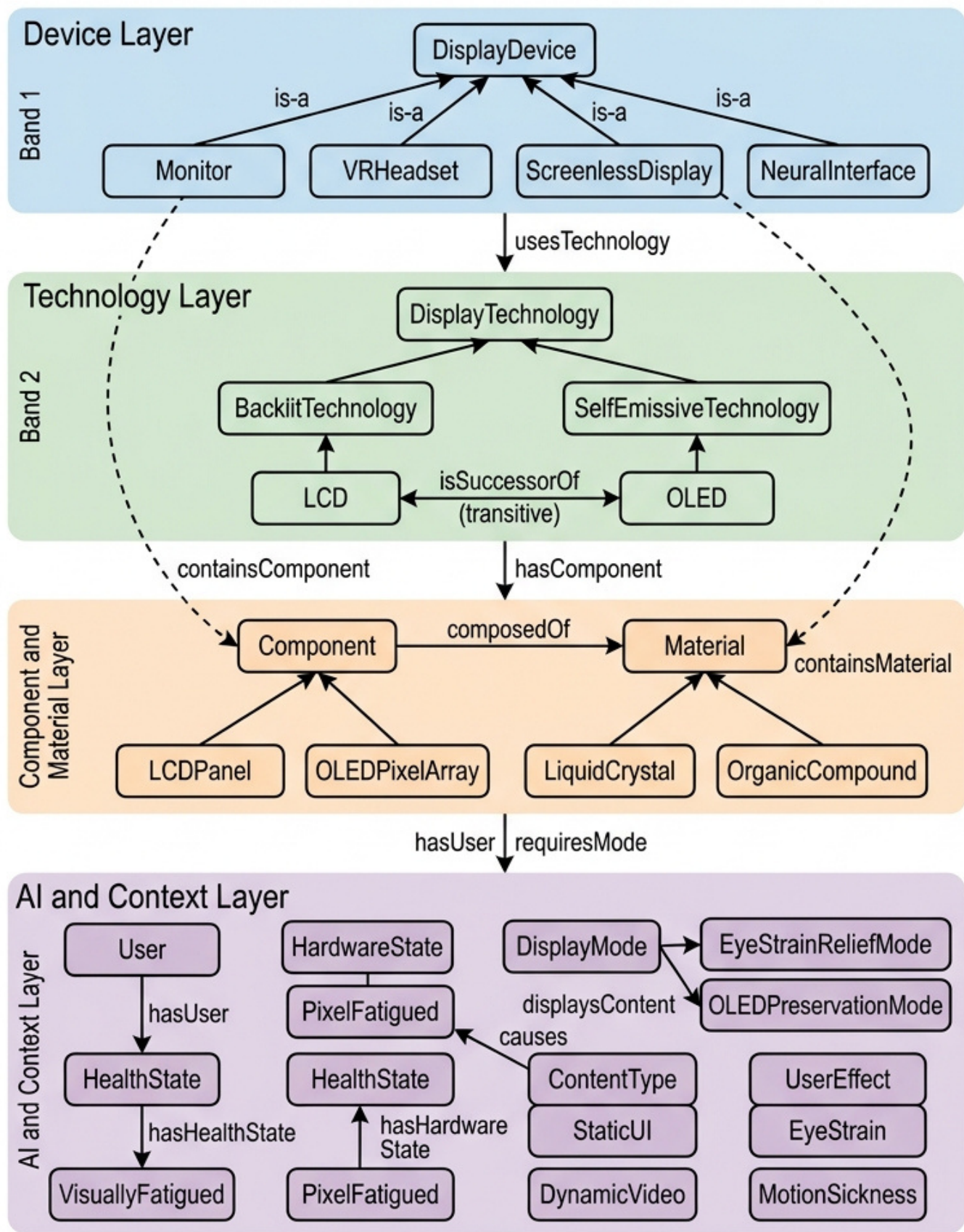


REVOLUTION

We redefine displays to include **ScreenlessDisplay** and **NeuralInterface**, extending **beyond physical screens** and even bypassing the eye.

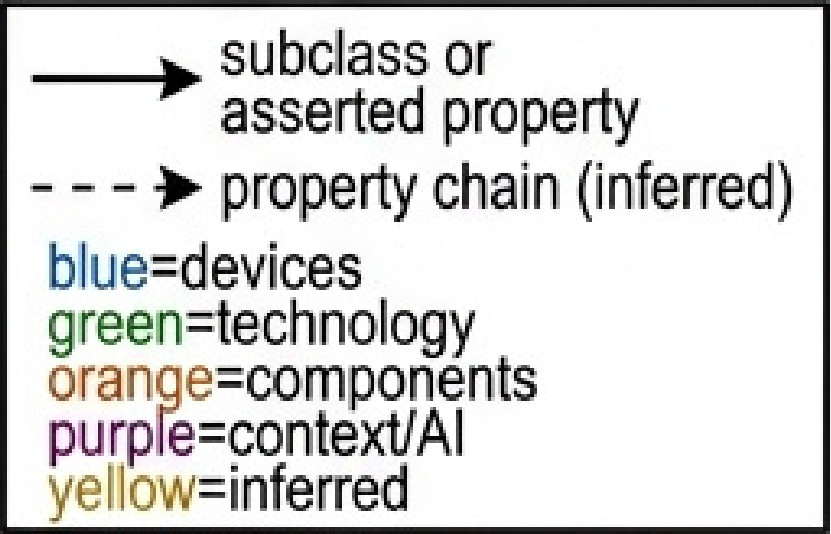
The **AI Awareness Engine** shifts the model from a passive output device to a context-aware adaptive agent.





Defined Classes (Reasoner Inferred)

- NauseaInducingVR**
VRHeadset + latency >= 20
OR Hz <= 90
- SubZeroUnsuitableDevice**
containsMaterial
LiquidCrystal
- HighDegradationRiskDevice**
OrganicCompound + StaticUI
- DeviceRequiringE-yeStrainRelief**
User hasHealthState
VisuallyFatigued
- AtRiskOLED**
pixelFatigue >= 70%
- DeviceRequiring OLEDPreservation**
containsComponent
AtRiskOLED



Three core properties:

- **usesTechnology**: connects a display device to its underlying display technology
- **hasComponent**: connects a technology to the physical component that implements it
- **composedOf**: connects a component to the material it is made from

Two derived properties

- **containsComponent**: derived: Device $\rightarrow$ Technology $\rightarrow$ Component
- **containsMaterial**: derived: Device $\rightarrow$ Technology $\rightarrow$ Component $\rightarrow$ Material

Property chains allow knowledge to travel across multiple layers without any manual intermediate assertion.

- **containsComponent** defined as: **usesTechnology** followed by **hasComponent**
- **containsMaterial** is defined as: **usesTechnology** followed by **hasComponent** followed by **composedOf**

Diagram illustrating the process of running a reasoner to infer property chains.

Left Panel (Initial State): Shows the ontology editor interface. The "Annotations" tab is active, displaying the definition of `vdo:containsComponent` as a chain of `usesTechnology` followed by `hasComponent`. The "Object properties" tab shows the hierarchy of properties, including `vdo:containsComponent`.

Center: An arrow labeled "RUNNING REASONER" points from the left panel to the right panel.

Right Panel (Resulting State): Shows the ontology editor interface after running the reasoner. The "Individuals" tab is active, displaying a list of individuals. The individual `vdo:Arctic_Research_Monitor` is highlighted, indicating it has been classified as a `SubZeroUnsuitableDevice` based on the inferred property chain.

Annotations: The right panel also shows the "Annotations" tab for `vdo:Arctic_Research_Monitor`, which now includes the inferred property chain `vdo:containsComponent` (defined as `usesTechnology` followed by `hasComponent` followed by `composedOf`).

The device is automatically classified as a `SubZeroUnsuitableDevice` – without any human labeling.

- **Latency (ms):** A VR headset with latency greater than or equal to 20 milliseconds is at risk of inducing motion sickness
- **Refresh rate (Hz):** A VR headset with refresh rate less than or equal to 90 Hz is at risk of inducing motion sickness
- **Pixel fatigue (%):** An OLED pixel array with fatigue greater than or equal to 70 percent is classified as at risk and enters a degraded hardware state

The image displays three screenshots of a Semantic Web editor interface, likely Protégé, showing class hierarchies and property assertions for a VR headset ontology.

Top Left Screenshot: Shows the class hierarchy for `vdo:AtRiskOLED`. The hierarchy is as follows:

- `owl:Thing`
 - `vdo:Component`
 - `vdo:LCDPanel`
 - `vdo:OLEDPixelArray`
 - `vdo:AtRiskOLED` (Selected)
 - `vdo:ContentType`
 - `vdo:DisplayDevice`
 - `vdo:DisplayMode`
 - `vdo:DisplayTechnology`
 - `vdo:HardwareState`
 - `vdo:HealthState`
 - `vdo:HumanOrgan`
 - `vdo:Material`
 - `vdo:UseCase`
 - `vdo:User`
 - `vdo:UserEffect`

The `Annotations` tab for `vdo:AtRiskOLED` is empty. The `Description` tab shows the following description:

Equivalent To: `vdo:OLEDPixelArray and (vdo:hasPixelFatiguePercentage some xsd:integer[>= 70])`

The `SubClass Of` tab shows the following sub-classes:

- `vdo:hasHardwareState some vdo:PixelFatigued`
- `vdo:OLEDPixelArray`

Top Right Screenshot: Shows the class hierarchy for `vdo:Cheap_VR_Headset`. The hierarchy is as follows:

- `owl:Thing`
 - `vdo:Airport_OLED_Board`
 - `vdo:Alice_Smart_Glasses`
 - `vdo:Arctic_Research_Monitor`
 - `vdo:Cheap_VR_Headset` (Selected)
 - `vdo:Hybrid_AI_Laptop`
 - `vdo:LCD_Panel_01`
 - `vdo:LCD_Tech_Standard`
 - `vdo:OLED_Array_01`
 - `vdo:OLED_Array_Degraded`
 - `vdo:OLED_Tech_Degraded`
 - `vdo:OLED_Tech_Premium`
 - `vdo:Raw_LiquidCrystal`
 - `vdo:Raw_OrganicCompound`

The `Annotations` tab for `vdo:Cheap_VR_Headset` is empty. The `Description` tab shows the following description:

Types: `vdo:VRHeadset` and `vdo:NauseaInducingVR`

The `Property assertions` tab shows the following assertions:

- `vdo:hasHzValue 60`
- `vdo:hasLatencyMs 25`

Bottom Screenshot: Shows the class hierarchy for `vdo:NauseaInducingVR`. The hierarchy is as follows:

- `owl:Thing`
 - `vdo:DisplayDevice`
 - `vdo:DeviceRequiringEyeStrainRelief`
 - `vdo:DeviceRequiringOLEDPreservation`
 - `vdo:HighDegradationRiskDevice`
 - `vdo:Monitor`
 - `vdo:NeuralInterface`
 - `vdo:ScreenlessDisplay`
 - `vdo:SubZeroUnsuitableDevice`
 - `vdo:VRHeadset`
 - `vdo:NauseaInducingVR` (Selected)
 - `vdo:DisplayMode`
 - `vdo:DisplayTechnology`
 - `vdo:HardwareState`

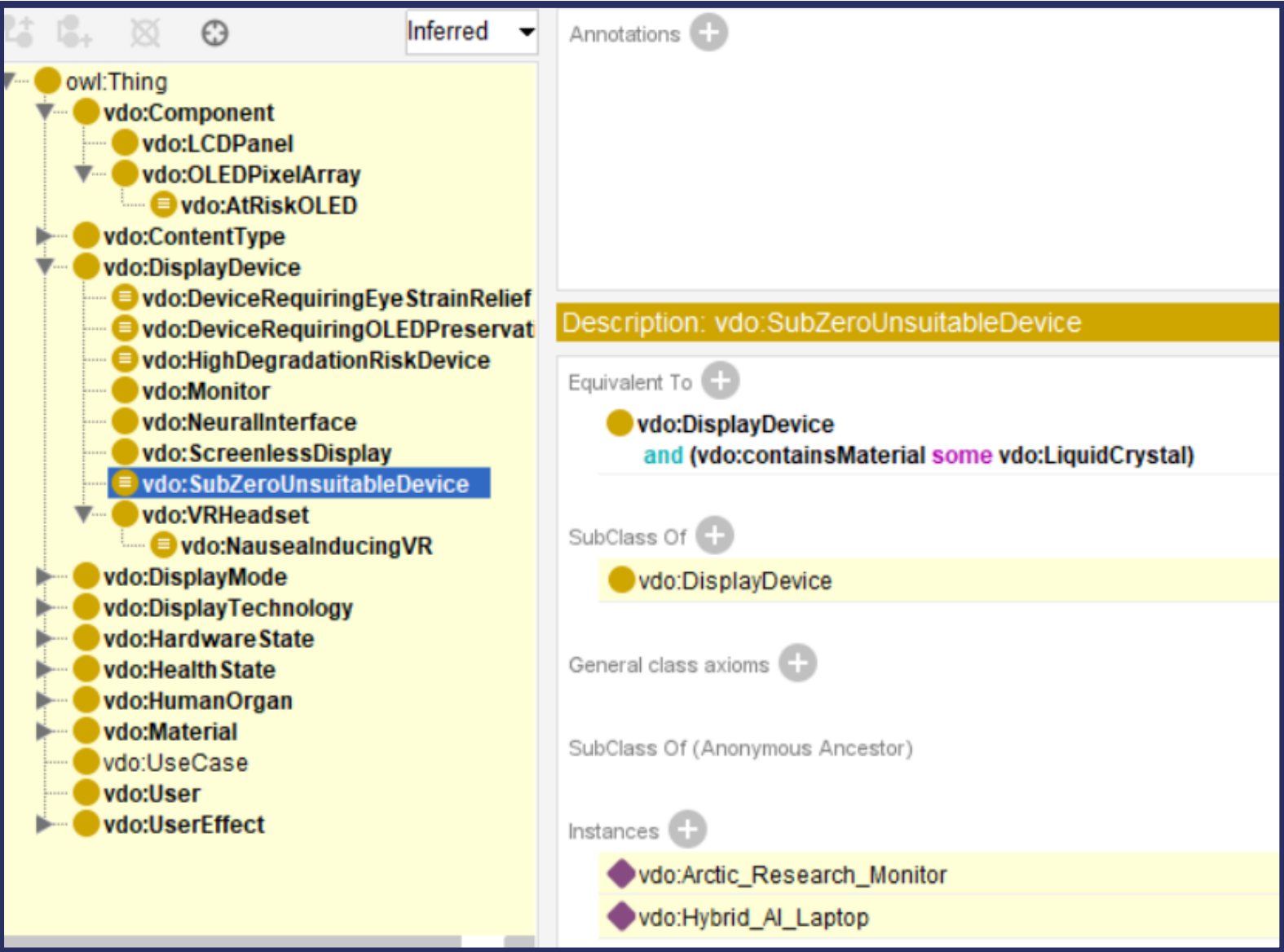
The `Description` tab for `vdo:NauseaInducingVR` shows the following description:

Equivalent To: `vdo:VRHeadset and ((vdo:hasHzValue some xsd:integer[<= 90]) or (vdo:hasLatencyMs some xsd:integer[>= 20]))`

The `SubClass Of` tab shows the following sub-classes:

- `vdo:causes some vdo:MotionSickness`
- `vdo:VRHeadset`

six inferred classes are defined using owl:equivalentClass, not rdfs:subClassOf.



- A subclass says: every member of A is also a member of B (one direction)
- An equivalent class says: A and B have exactly the same members (both directions)

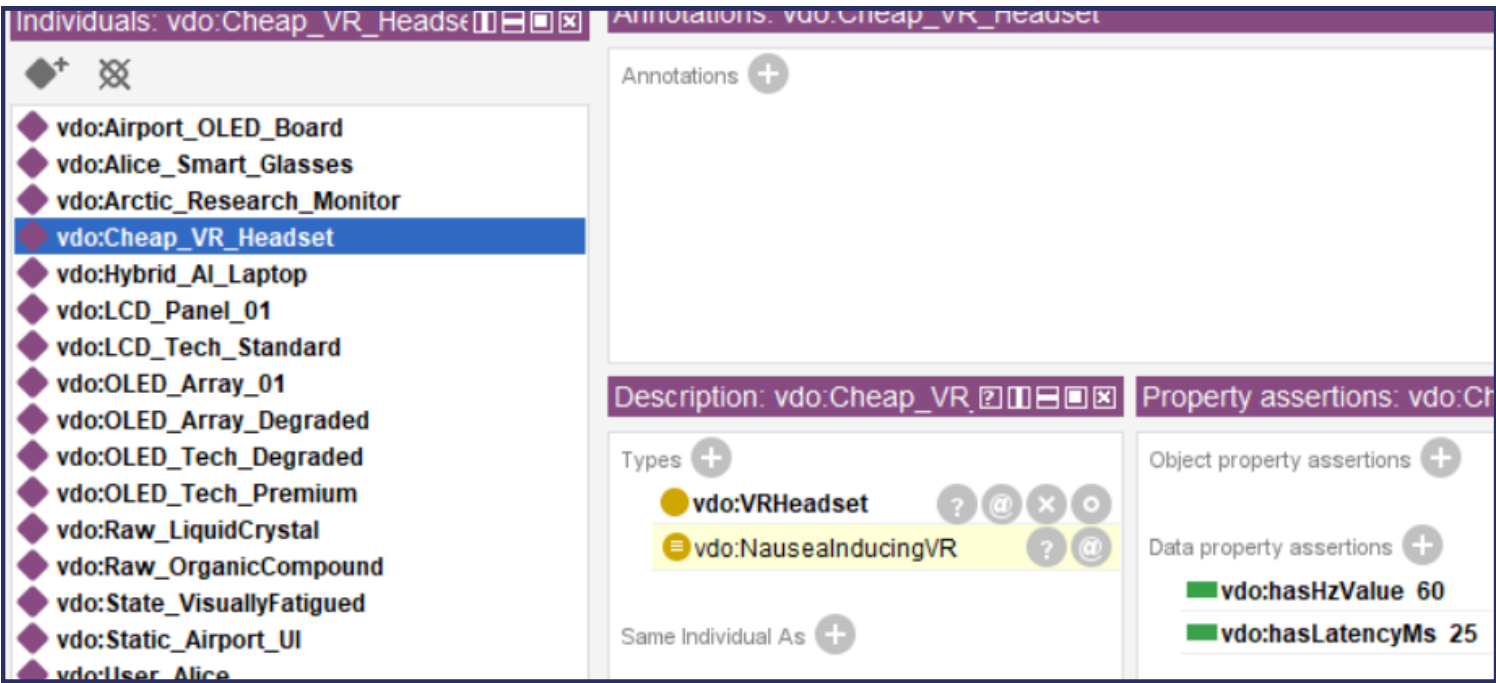
Class

What triggers it

NauseaInducingVR	VR headset with bad latency or low refresh
SubZeroUnsuitableDevice	Device containing Liquid Crystal material
HighDegradationRiskDevice	OLED device displaying static content
DeviceRequiringEyeStrainRelief	Device used by a visually fatigued user
AtRiskOLED	OLED component with pixel fatigue 70% or above
DeviceRequiringOLEDPreservation	Device containing an at-risk OLED component

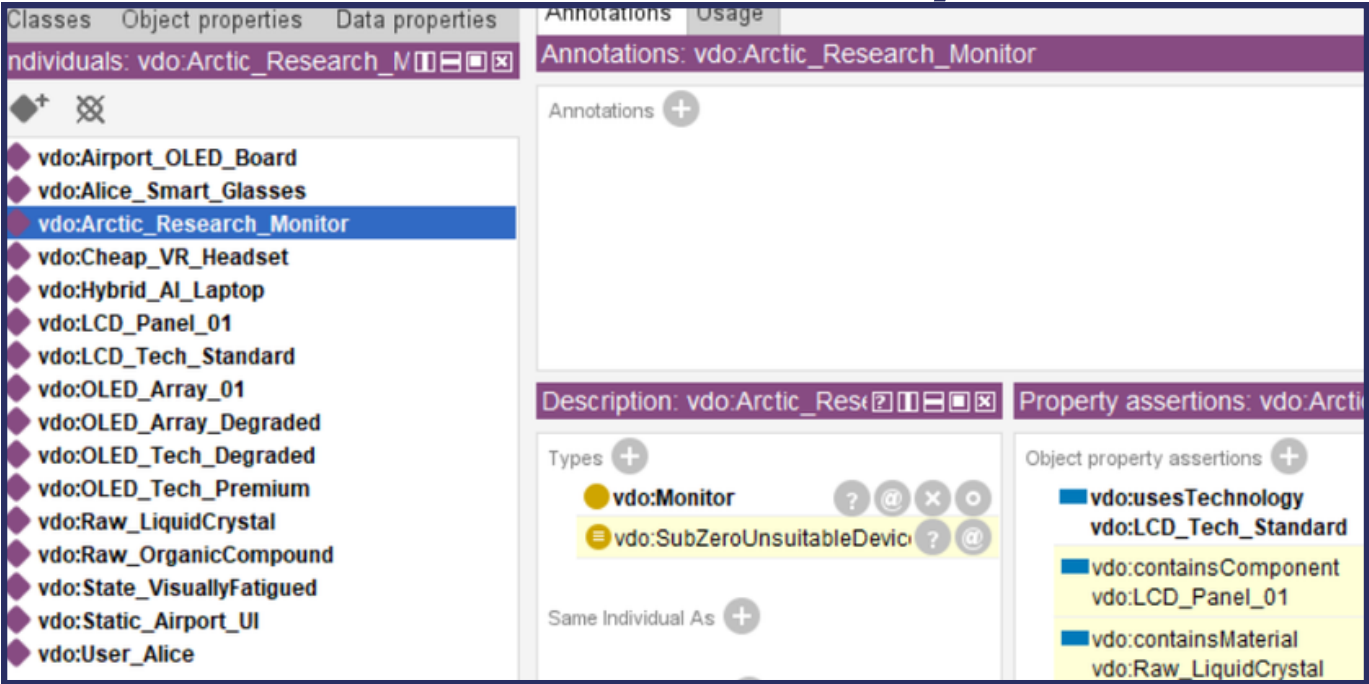


Use Case: VR Motion Sickness



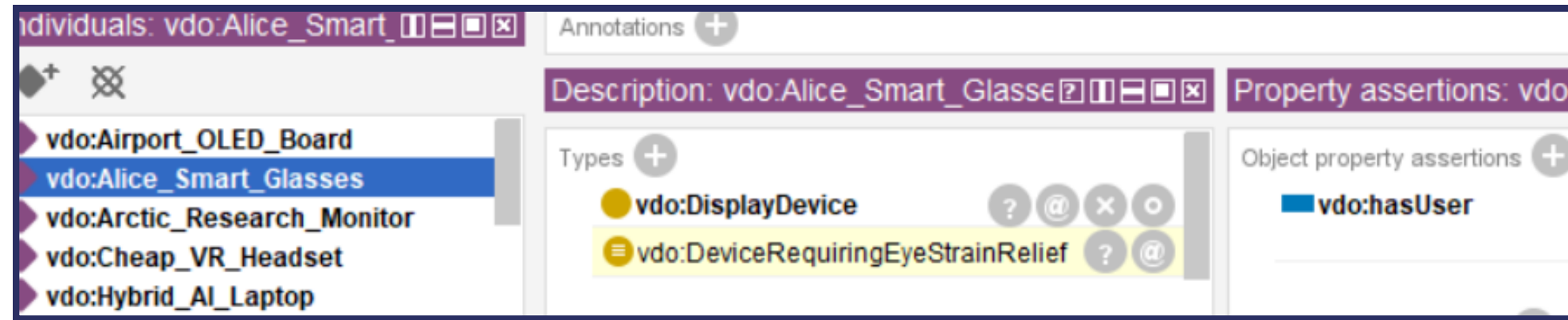
The logic: The class NauseaInducingVR is defined as any VR headset that has latency at or above 20 milliseconds OR refresh rate at or below 90 Hz.

Use Case: Cold Unsuitability



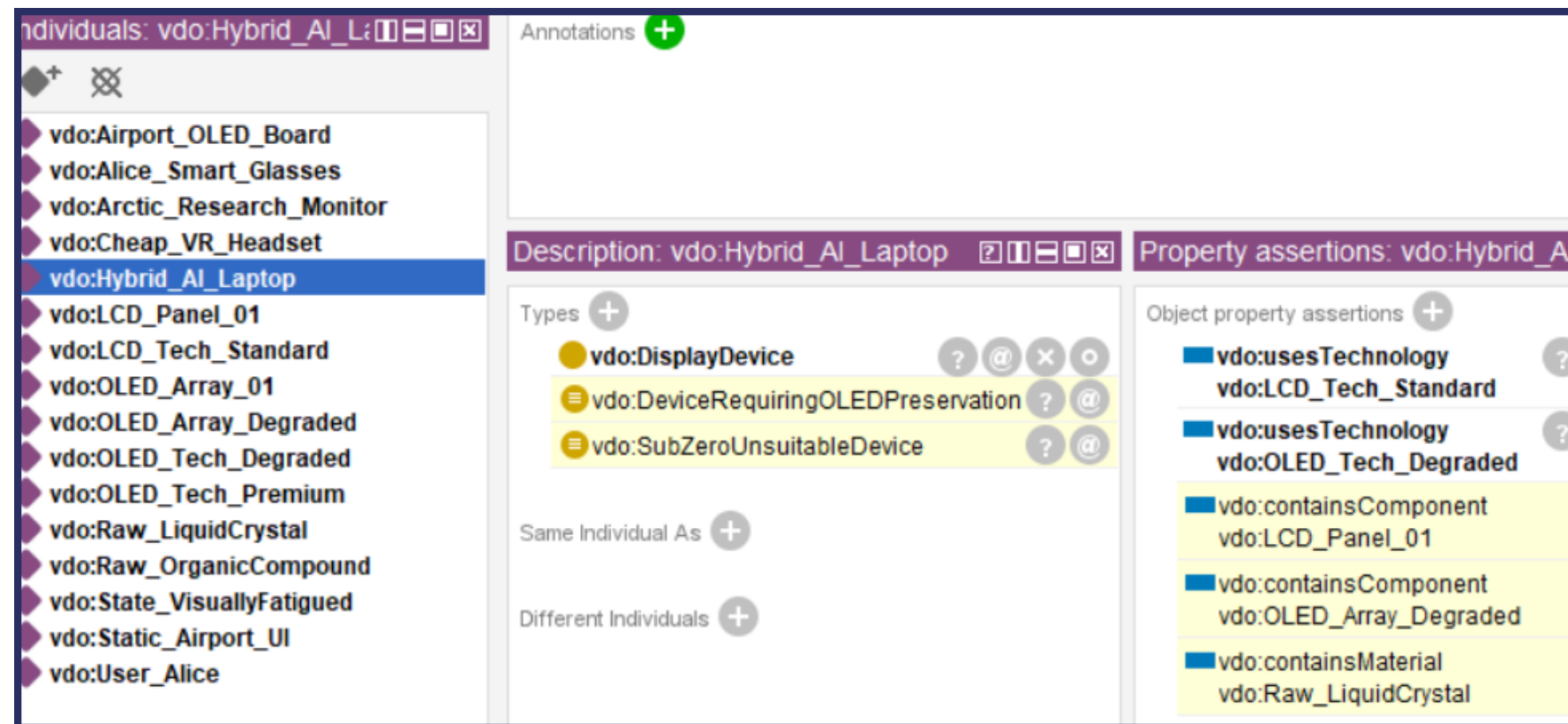
The logic: The class SubZeroUnsuitableDevice is defined as any display device that contains liquid crystal material – reached through the containsMaterial property chain..

Use Case: User-Aware Adaptation



The logic: The class **DeviceRequiringEyeStrainRelief** is defined as any display device that has a user, where that user has a health state of **VisuallyFatigued**. This class is also a subclass of "**requiresMode some EyeStrainReliefMode**."

Use Case: Hardware-Aware Adaptation



The full chain:

1. The OLED pixel array has hasPixelFatiguePercentage = 85
2. The reasoner classifies it as AtRiskOLED (threshold is 70%)
3. AtRiskOLED is inferred to have hardware state PixelFatigued
4. The Hybrid AI Laptop uses a technology that contains this AtRiskOLED component
5. Therefore the laptop is classified as DeviceRequiringOLEDPreservation
6. Which is inferred to requiresMode OLEDPreservationMode

What is automatically inferred from raw assertions:

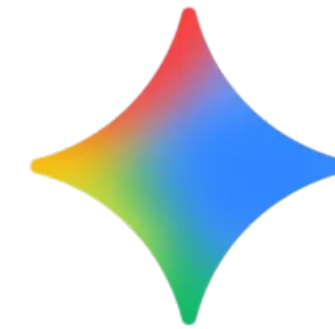
- **Risk classification:** devices flagged for cold environments, burn-in, or motion sickness
- **Human effects:** motion sickness linked to VR headsets with bad metrics
- **Hardware states:** pixel fatigue above threshold triggers PixelFatigued state
- **Required display modes:** EyeStrainReliefMode and OLEDPreservationMode recommended automatically

The value:

- **Any new device added to the ontology with appropriate property assertions will be classified correctly without any additional rules or code.**

Tools and Components:

- Protégé 5.6
- OWL 2 DL
- HermiT reasoner
- Claude Sonnet 4.6 Thinking model (Documentation)
- Gemini 3 Pro Image (Visuals)
- SciSpace Ai / Perplexity (Research)



1. **Open World Assumption:** OWL assumes that missing information is unknown, not false.
2. **No disjointness axioms**
3. **No real-time data integration**

Near-Term:

- **Disjointness** axioms between **sibling classes** to enable **consistency checking**
- Activate **hasPWMFrequency** with a **migraine trigger axiom** (any technology with PWM frequency below 240 Hz is a PotentialMigraineTrigger)
- Declare **UseCase subclasses** (Gaming, Reading, OutdoorUse) and wire the **optimizedFor** property

Longer-term(the **Revolution** roadmap):

- Add **MicroLED**, **E-Ink**, and **HolographicDisplay** as technology subclasses
- Add **ScreenlessDisplay** assertions and the **bypassesOrgan** property on **NeuralInterface**
- Introduce **EnvironmentalCondition** (ambient light, temperature) and connect it to device suitability rules
- Integrate a real sensor pipeline using **OWLready2** for live state updates
- Combine with an **AI perception layer** for full **neuro-symbolic** operation

From Display Devices Ontology → to Adaptive Visual Experience Ontology.

The knowledge existed in spec sheets and research papers; this ontology makes it computable and self-reasoning.

The display is no longer something you look at, it is a system that looks back, reasons about you, and adapts.

THANK YOU
For Your Attention



Appendix

