# Strategic Technical Blueprint: Emotion-Adaptive Shopping Interface for the AMD Slingshot Hackathon

## 1. Executive Strategy and Hackathon Alignment

### 1.1 Project Vision and Thematic Fit

The proposed project, "Emotion-Adaptive Shopping Interface," represents a paradigmatic shift in e-commerce, moving beyond transactional exchanges to **Affective Commerce**. By proposing a browser-agnostic overlay that dynamically adjusts the user interface (UI), product recommendations, and pricing incentives based on real-time physiological and behavioral signals, the team addresses the core theme of the AMD Slingshot Hackathon: "AI in Consumer Experiences".[1]

The current digital retail landscape suffers from a "one-size-fits-all" rigidity. Whether a user is browsing for leisure (high openness, low urgency) or frantically replacing a broken laptop (high stress, high urgency), platforms like Amazon and Flipkart present identical interfaces. This emotional disconnect leads to decision fatigue, cart abandonment, and suboptimal user satisfaction. Your solution acts as an empathetic intermediary, utilizing **Edge AI** to bridge the gap between user intent and digital response.

For a team of three 6th-semester Computer Engineering students, this project is strategically calibrated. It is ambitious enough to demonstrate technical depth—spanning computer vision, browser engineering, and hardware acceleration—yet modular enough to achieve a Minimum Viable Product (MVP) within the hackathon timeframe. The key differentiator is the architectural decision to overlay existing platforms rather than building a mock e-commerce site. This "parasitic" or "symbiotic" architecture demonstrates immediate real-world applicability, a critical factor for the "Startup Idea Challenge" nature of the Slingshot competition.[3]

### 1.2 The "AMD Advantage" Strategy

To win the AMD Slingshot Hackathon, the utilization of AMD hardware must not be incidental; it must be foundational. The judging criteria prioritize technical execution and the innovative use of the provided stack, specifically the **AMD Ryzen™ AI** ecosystem.[5]

The critical strategic argument for this project is **Privacy-Preserving Latency**. An emotion-adaptive interface requires continuous video stream analysis. Offloading this to the cloud is non-viable for two reasons:

1. **Latency:** The "round trip" time for a frame to travel to a server and back breaks the real-time feedback loop required for UI adaptation.
2. **Privacy:** Users are increasingly hostile toward applications that stream webcam footage to remote servers.

This creates the perfect use case for the **AMD Ryzen™ AI NPU (Neural Processing Unit)** based on the XDNA™ architecture. By performing inference locally on the NPU, the application ensures that raw video data never leaves the device.[7] Furthermore, offloading the AI workload to the NPU frees up the CPU and GPU to handle the heavy JavaScript execution and rendering required by modern Single Page Applications (SPAs) like Amazon, ensuring a stutter-free browsing experience.[9] This hardware-software synergy forms the core narrative of your pitch: *Ethical, invisible, and efficient AI*.

## 1.3 Judging Criteria Analysis

Based on historical data from AMD hackathons and the 2025/2026 Slingshot guidelines, the project will be evaluated on three pillars:

| Evaluation Pillar | Hackathon Expectation | Project Strategy |
|---|---|---|
| **Innovation (30%)** | Novel application of AI, not just a wrapper. | Shift from click-based to emotion-based personalization. Using "Affective Computing" in a domain (retail) dominated by collaborative filtering. |
| **Technical Execution (40%)** | Effective use of AMD ROCm, Ryzen AI, NPU. | Implementation of the "Sidecar" pattern using Native Messaging. Usage of **ONNX Runtime with Vitis AI EP**. Demonstration of INT8 quantization using **AMD Quark**. |
| **Business Viability (30%)** | Real-world problem, scalability, startup potential. | Addressing the $18 billion cart abandonment problem. The "Overlay" model means zero integration cost for retailers, allowing for a B2C freemium or B2B2C data |

|  |  |  |
|---|---|---|
|  |  | model. |

## 2. Theoretical Framework: Affective Commerce and Consumer Psychology

To build an effective AI, we must first understand the psychological signals we are attempting to decode. This section provides the theoretical underpinning for the "Emotion-Adaptive" logic, ensuring the AI's actions are grounded in behavioral science.

### 2.1 The Psychology of the Digital Shopper

Modern e-commerce is plagued by **Decision Paralysis**, often triggered by the "Paradox of Choice." When a user is presented with too many options under high cognitive load (stress), conversion rates drop. Conversely, under low arousal (boredom), users require stimulation to engage.

The "Emotion-Adaptive Shopping Interface" functions as a **Digital Pharmacist**, dispensing UI interventions based on the diagnosed emotional state:

- **High Arousal + Negative Valence (Stress/Frustration):** The user is overwhelmed. The system must reduce cognitive load (remove clutter, simplify choices).
- **Low Arousal + Positive Valence (Relaxation/Browsing):** The user is open to discovery. The system should encourage exploration and serendipity.
- **High Arousal + Positive Valence (Excitement/Impulse):** The user is prone to impulsive financial decisions. The system (acting ethically) might introduce "friction" to ensure responsible spending, or (acting commercially) capitalize on the moment.

### 2.2 Biological Signals and Inference

The project relies on **Remote Photoplethysmography (rPPG)** principles and **Facial Action Coding System (FACS)**. While rPPG (heart rate from video) is computationally expensive, FACS (micro-expressions) is highly effective for webcam-based inference.

The AI will categorize facial landmarks into discrete emotional buckets relevant to shopping:

1. **Confusion:** Brow furrowing (Action Unit 4), head tilt, narrowing of eyes.
2. **Delight/Surprise:** Raising of eyebrows (AU 1+2), mouth opening, smiling.
3. **Disgust/Skepticism:** Nose wrinkling (AU 9), lip corner depression.
4. **Neutral/Boredom:** Lack of muscle activation, gaze fixation or wandering.

### 2.3 The Feedback Loop Mechanism

The system operates on a **Perception-Action Cycle**:

1. **Sensing:** The camera captures the raw data.
2. **Perception:** The NPU infers the emotional state (e.g., "Confusion: 85%").
3. **Decision:** The logic layer maps "Confusion" to a UI strategy (e.g., "Simplify Layout").
4. **Action:** The extension injects CSS/JS to hide sidebars and highlight reviews.
5. **Feedback:** The system monitors if the "Confusion" metric decreases, reinforcing the successful intervention.

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## 3. Hardware Architecture: Deep Dive into AMD Ryzen AI

This section details *why* and *how* the AMD hardware stack is utilized. This is critical for the "Technical Execution" score. The judges need to see that you understand the silicon you are running on, not just the Python libraries.

### 3.1 The XDNA Architecture

The Ryzen AI NPU utilizes the **AMD XDNA™ architecture**. Unlike the "Von Neumann" architecture of a CPU (where data moves back and forth between memory and compute units, creating a bottleneck), XDNA is a **Spatial Dataflow Architecture**.[11]

In XDNA, the "compute tiles" are arranged in a grid with local memory. The data flows through the grid like an assembly line. This is particularly effective for Convolutional Neural Networks (CNNs) used in vision tasks, where the output of one layer is the immediate input of the next.

**Implication for the Project:**

- **Determinism:** The NPU provides consistent latency, which is crucial for a UI overlay. A GPU might be momentarily hijacked by a WebGL animation on the webpage, causing the AI to lag. The NPU remains dedicated to the emotion recognition task.
- **Adaptive Power Management:** For a student hackathon, demonstrating that your application can run on a battery-powered laptop for hours is a significant "User Experience" win. The NPU consumes a fraction of the power of the iGPU for the same inference workload.[13]

### 3.2 Ryzen AI Software Stack (Version 1.7)

The team will utilize **Ryzen AI Software 1.7**, the latest release offering unified installer support and improved quantization tools.[14] The stack consists of four layers:

1. **Hardware Layer:** AMD Ryzen 7040/8040/AI 300 Series Processor (NPU + Zen 4/5 CPU + RDNA 3 GPU).
2. **Driver Layer:** AMD NPU Driver (MCDM - Microsoft Compute Driver Model).
3. **Compiler Layer: Vitis AI Quantizer** and Graph Compiler. This compiles the neural

network into an .xclbin (firmware binary) that the NPU can execute.
4. **Runtime Layer: ONNX Runtime (ORT)** with the **Vitis AI Execution Provider (VOE)**. This is the API surface the Python backend will interact with.

### 3.3 Latency and Throughput Analysis

In a browser overlay scenario, latency is perceptually critical. If the user frowns, the UI must adapt within 200-500ms to feel "responsive."

- **CPU Inference (Baseline):** On a Zen 4 CPU, a ResNet-18 model might take 15-30ms per frame. However, this spikes CPU usage to 40-50%, causing the browser fan to spin up.
- **GPU Inference (iGPU):** Fast (5-10ms), but competes with browser compositing (rendering the HTML/CSS).
- **NPU Inference (Target):** With **Int8 quantization**, the NPU can achieve sub-10ms latency with negligible CPU impact.[15] This "Headroom" allows the main processor to render the complex overlay animations smoothly.

### 3.4 Quantization Strategy with AMD Quark

The NPU is an integer-first engine. While it can handle floating-point math, its peak TOPS (Trillions of Operations Per Second) are unlocked using **Int8** or **Block FP16**. The team will use the **AMD Quark** quantization tool.[12]

The workflow involves:

1. **Pre-processing:** Taking a standard PyTorch model (Float32).
2. **Calibration:** Running a subset of the dataset (e.g., 100 images from FER2013) through the model to determine the dynamic range of activations.
3. **Quantization:** Mapping the 32-bit floating-point numbers to 8-bit integers.
4. **Compilation:** Generating the ONNX model optimized for the specific NPU architecture.

This process typically yields a **4x reduction in model size** and a **3x increase in throughput** compared to the CPU baseline, a metric that must be highlighted in the final presentation.

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## 4. Software Architecture: The Extension-Sidecar Pattern

Designing an application that overlays a secure browser environment while accessing local hardware requires a specific architectural pattern. Standard Chrome Extensions (Manifest V3) are sandboxed; they cannot load arbitrary binary libraries or access the NPU drivers directly. Therefore, we employ the **Extension-Sidecar Pattern**.

## 4.1 System Components and Interaction

The system comprises three distinct execution environments communicating asynchronously:

1. **The Content Script (Browser Context):**
   - **Role:** The eyes and hands of the system. It runs *inside* the Amazon/Flipkart tab.
   - **Privileges:** Access to DOM, Limited access to Chrome APIs. No access to file system or hardware drivers.
   - **Tech:** JavaScript (React), Shadow DOM.
2. **The Background Service Worker (Extension Context):**
   - **Role:** The coordinator. It bridges the gap between the Content Script and the Native Host.
   - **Privileges:** Access to chrome.runtime.sendNativeMessage.
   - **Tech:** JavaScript.
3. **The Native Host (System Context):**
   - **Role:** The brain. It is a standalone Python executable running on the user's OS.
   - **Privileges:** Full access to NPU, File System, Network.
   - **Tech:** Python, ONNX Runtime, FastAPI (optional).

## 4.2 Inter-Process Communication (IPC) Flow

The data flow for a single inference cycle is as follows:

1. **Capture:** The Content Script captures a video frame from the webcam using a hidden <video> element and draws it to an off-screen <canvas>.
2. **Serialization:** The canvas data is converted to a Base64 string (JPEG format to save bandwidth).
3. **Message Passing (Internal):** The Content Script sends the Base64 string to the Service Worker via chrome.runtime.sendMessage.
4. **Message Passing (Native):** The Service Worker forwards this message to the Python Native Host using chrome.runtime.sendNativeMessage.[18]
5. **Deserialization:** The Python script reads the message from stdin (Standard Input). It decodes the Base64 string back into a NumPy array (image).
6. **Inference:** The Python script passes the NumPy array to the Ryzen AI NPU via ONNX Runtime.
7. **Response:** The NPU returns the emotion probabilities. The Python script selects the highest probability emotion and writes a JSON response to stdout (Standard Output).
8. **Callback:** The Service Worker receives the JSON and forwards it to the Content Script.
9. **Actuation:** The Content Script triggers a React state change, updating the UI overlay.

## 4.3 Native Messaging Implementation Details

Implementing the "Bridge" requires strict adherence to the Chrome Native Messaging protocol. The Python script does not just "print" text. It must send a **4-byte length prefix** before the JSON message.

**Protocol Specification:**

- **Input (Chrome -> Python):** A 32-bit integer (native byte order) specifying the message length, followed by the JSON string.
- **Output (Python -> Chrome):** Same format.

**Failure Mode Handling:**

If the Python script crashes (e.g., driver error), the Service Worker must detect the disconnect and attempt to restart the "port" or notify the user. This robustness is key for a hackathon demo.

### 4.4 Security Considerations (Manifest V3)

Google's Manifest V3 enforces strict Content Security Policies (CSP).

- **Remote Code:** We cannot download code from the internet. The Python logic is safe because it runs outside the browser sandbox.
- **Cross-Origin:** The Content Script cannot make arbitrary fetch requests to third-party APIs (like a price checker) unless those domains are listed in the manifest.json.
- **Privacy:** The Python script acts as a "Data Vault." It processes images in RAM and discards them immediately. This architectural guarantee is a strong selling point for the "Privacy" track.

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## 5. The AI Pipeline: From Webcam to Inference

This section details the specific AI implementation, moving from the conceptual to the code level. This is the "How-To" for the AI Engineer on the team.

### 5.1 Model Selection Strategy

For a browser overlay, the model must be small (<20MB) and fast. Large Transformer models are overkill for basic emotion detection and will induce lag.

**Recommended Model: Mini-Xception (FER2013)**

- **Architecture:** Convolutional Neural Network (CNN) based on Xception (Depthwise Separable Convolutions).
- **Input:** 64x64 pixel grayscale images.
- **Output:** 7 classes (Angry, Disgust, Fear, Happy, Sad, Surprise, Neutral).
- **Why:** It offers the best balance of accuracy (approx. 66% on FER2013, sufficient for UX adaptation) and speed.

**Alternative: ResNet-18 (AffectNet)**

- **Architecture:** Residual Network.
- **Input:** 224x224 RGB images.
- **Why:** Higher accuracy on "in-the-wild" faces but computationally heavier. On the Ryzen AI NPU, ResNet-18 runs incredibly fast, so this is a viable "High Quality" option.

## 5.2 The Quantization Workflow (AMD Quark)

To run on the NPU, the model essentially needs to be converted from a "precise but slow" mathematician (Float32) to a "fast estimator" (Int8).

**Step 1: Calibration Data Preparation**

Create a folder with 100-200 representative face images. These do not need to be labeled; they are used solely to measure activation distributions.

**Step 2: Quantization Code (Conceptual)**

Python

```python
# Import AMD Quark / Vitis AI Quantizer
from pytorch_nndct.apis import torch_quantizer

# Load Float32 Model
model = load_model("mini_xception.pth")
dummy_input = torch.randn()

# Create Quantizer
quantizer = torch_quantizer("calib", model, (dummy_input), device=device)

# Forward pass with calibration data
for image in calibration_loader:
    quantizer.model(image)

# Export Quantized ONNX
quantizer.export_onnx_model()
```

This process generates mini_xception_int8.onnx, which is ready for the NPU.

## 5.3 Face Detection Optimization

Before emotion recognition, the system must find the face. Running a Deep Learning face detector (like MTCNN) on every frame is expensive.

**Optimization Strategy:**

1. **Hybrid Approach:** Use a lightweight detector (e.g., Ultra-Light-Fast-Generic-Face-Detector-1MB) running on the **CPU** or **iGPU**. It is extremely fast.
2. **Temporal Coherence:** Faces do not teleport. If a face is found at coordinates (x,y) in Frame 1, search only a small region around (x,y) in Frame 2. Run the full detector only every 10 frames or if tracking is lost.
3. **Inference:** Once the face is cropped, send *only* the 64x64 crop to the NPU for emotion recognition.

### 5.4 Gaze Tracking (The "Attention" Metric)

To analyze *what* the user is looking at (e.g., the price vs. the picture), we need Gaze Tracking.

- **Library: Ryzen AI CVML Library**.[19] AMD provides optimized libraries for common Computer Vision tasks.
- **Functionality:** It returns the pitch, yaw, and roll of the head.
- **Heuristic:** If the head yaw is 0 (center) and pitch is 0, the user is looking at the center. If yaw is negative, they are looking left (e.g., at the image gallery on Amazon).

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## 6. Frontend Engineering: The Overlay and DOM Manipulation

The frontend is where the AI meets the user. The challenge is injecting a complex React application into a hostile environment (a third-party website with its own complex CSS and JS) without breaking anything.

### 6.1 Shadow DOM: The Immune System

Standard CSS is global. If your extension defines a .button class, and Amazon also has a .button class, the styles will clash (the "Cascading" in CSS).

**Solution: Open Shadow DOM**

The Shadow DOM creates a scoped subtree. Styles defined inside do not leak out, and page styles do not leak in.

**Implementation Logic:**

1. **Injection Point:** The Content Script appends a div (e.g., <div id="emotion-ai-host">) to

the document.body.
2. **Shadow Attachment:** It calls const shadowRoot = host.attachShadow({mode: 'open'}).
3. **Style Injection:** Because Tailwind CSS generates utility classes, these classes must exist *inside* the Shadow Root. We must bundle the compiled Tailwind CSS as a string and inject it into a <style> tag within the shadow root.[20]
4. **React Mounting:** The React application root is rendered into the shadowRoot, not the host.

### 6.2 Heuristic DOM Analysis (The "scraper")

To adapt the UI, the system must understand the page context.

- **Context Detection:**
  - *Is this a Product Page?* Check for elements like #productTitle (Amazon) or .B_NuCI (Flipkart).
  - *Is this the Cart?* Check URL for /cart or /checkout.
- **Element Mapping:**
  - **Price:** span.a-price-whole (Amazon).
  - **Image:** #landingImage (Amazon).
  - **Buy Button:** #add-to-cart-button.
- **Resilience:** Since class names change, the scraper should use **Semantic Selectors** where possible (e.g., [aria-label="Add to cart"]) or fallback lists.

### 6.3 React State Management

The React app in the overlay maintains a state machine:

- **Idle:** Monitoring.
- **Active - Intervention:** Emotion threshold crossed (e.g., Anger > 70%).
- **Feedback:** User interacting with the overlay (e.g., dismissing a "calm down" prompt).

This state is driven by the stream of messages coming from the Background Service Worker.

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## 7. Ten Effective MVP Features for Judges

To qualify and impress, the features must demonstrate **utility**, **novelty**, and **technical complexity**. Here are the top 10 MVP features, ranked by impact.

### Feature 1: The "Impulse Shield" (Financial Wellness)

- **The Trigger:** High Arousal (Excitement) + Gaze fixed on "Buy Now" + Fast mouse movement.
- **The Action:** The "Buy Now" button visually "cools down" (turns blue/grey). A micro-interaction asks, *"Quick breath! Do you need this today?"*

- **Tech:** Emotion Recognition (NPU) + Gaze Tracking + DOM Injection.
- **Why it Wins:** Promotes Responsible AI and financial wellness.

## Feature 2: "Zen Mode" (Cognitive Load Reduction)

- **The Trigger:** Confusion (Brow Furrow) + Rapid Scrolling (Searching behavior).
- **The Action:** The overlay injects CSS to hide "Sponsored Products," "Related Items," and banner ads. It highlights the Product Description and Rating.
- **Tech:** Confusion Detection + CSS Class Toggling.
- **Why it Wins:** Solves "Decision Fatigue." Accessibility win.

## Feature 3: Dynamic Review Filtering (The Skeptic's Lens)

- **The Trigger:** Skepticism/Disgust (Nose wrinkle) while reading reviews.
- **The Action:** The review section automatically re-sorts to show "Critical" (1-3 star) reviews and "Verified Purchase" tags only.
- **Tech:** Emotion Recognition + DOM Sorting Script.
- **Why it Wins:** Aligns platform behavior with user intent (validating their skepticism).

## Feature 4: The "Hype-Meter" (Price Reality Check)

- **The Trigger:** Surprise/Delight upon page load (reaction to a "50% Off" banner).
- **The Action:** The AI checks the *historical* price (via API). If the "deal" is fake (price hiked before dropping), the overlay glows Red. If genuine, it glows Green.
- **Tech:** Emotion + External Price API.[21]
- **Why it Wins:** Consumer protection. High utility.

## Feature 5: Adaptive Color Psychology

- **The Trigger:** Low Valence (Sadness/Lethargy).
- **The Action:** The browser overlay tints the white-space with warm, energetic hues (subtle peach/yellow) to boost mood.
- **Tech:** Real-time CSS variable injection (backdrop-filter).
- **Why it Wins:** "Subconscious" UX personalization. Visually impressive demo.

## Feature 6: Comparative Gaze Summarizer

- **The Trigger:** User oscillating between two product tabs.
- **The Action:** A popup appears: *"You spent 30s more looking at the Sony headphones than the Bose. Here is a quick comparison."*
- **Tech:** Gaze Tracking (Time-on-Page) + Tab Communication.
- **Why it Wins:** Uses "Agentic" behavior to assist decision making.

## Feature 7: "Mochi" Accessibility Mode

- **The Trigger:** Strain (Squinting, leaning closer to webcam).

- **The Action:** Automatically increases font size, contrast, and reads the product title aloud.
- **Tech:** Facial Landmark Depth Estimation (Leaning) + Browser Accessibility APIs.
- **Why it Wins:** Inclusivity. (Inspired by Google Chrome AI Challenge winners [23]).

### Feature 8: The "Bot Spotter" Warning

- **The Trigger:** User is reading a product with suspicious review patterns.
- **The Action:** Independent of emotion, if the AI detects bot-like review clusters (using a small NPU-based NLP model), it overlays a "Caution" icon. If the user looks "Trusting" (Happy), the warning pulses to get attention.
- **Tech:** NLP (DistilBERT on NPU) + Emotion.
- **Why it Wins:** Uses the NPU for NLP, not just vision.[24]

### Feature 9: Gamified "Boredom Buster"

- **The Trigger:** Neutral/Bored expression for >30 seconds.
- **The Action:** A small character (e.g., a "Deal Spirit") animates in the corner, offering a "Treasure Hunt" (find a hidden discount code).
- **Tech:** Temporal Emotion Tracking (State Machine).
- **Why it Wins:** Re-engages the user. Fun factor.

### Feature 10: Post-Purchase "Regret" Button

- **The Trigger:** Negative micro-expression immediately after the "Thank You" page loads.
- **The Action:** A prominent "Undo/Cancel Order" button appears immediately (saving the user from digging through menus).
- **Tech:** Micro-expression analysis (High speed inference).
- **Why it Wins:** Solves the "Buyer's Remorse" friction point immediately.

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## 8. Implementation Roadmap and Workflow

### Phase 1: The Foundation (Week 1-2)

- **Goal:** "Hello World" on the NPU.
- **Task 1:** Set up the Ryzen AI development environment.
- **Task 2:** Run the standard AMD ResNet50 sample on the NPU to verify drivers.
- **Task 3:** Create the basic Chrome Extension manifest and ensure Native Messaging works (Python script prints to Extension console).

### Phase 2: The Eye (Week 3-4)

- **Goal:** Real-time Emotion Inference.
- **Task 1:** Quantize the Mini-Xception model using AMD Quark.

- **Task 2:** Build the Python loop: Capture Frame -> Preprocess -> NPU Inference -> Output Emotion.
- **Task 3:** Optimize latency. Ensure the Python loop runs at >15 FPS with <10% CPU usage.

### Phase 3: The Hand (Week 5-6)

- **Goal:** Browser Overlay.
- **Task 1:** Implement Shadow DOM injection on Amazon.com.
- **Task 2:** Create the React components for "Zen Mode" and "Impulse Shield."
- **Task 3:** Connect the Python emotion stream to the React state.

### Phase 4: Integration and Polish (Week 7-8)

- **Goal:** MVP Features.
- **Task 1:** Implement specific scraping logic for Amazon/Flipkart (Price, Buy Button).
- **Task 2:** Refine the UI animations (using Tailwind).
- **Task 3:** "Dogfooding" - Use the extension while actually shopping to tune sensitivity thresholds.

### Phase 5: The Pitch Preparation (Pre-Submission)

- **Goal:** Judging Assets.
- **Task 1: Video Demo:** Record a split-screen video. Top: User face (showing emotions). Bottom: Website adapting in real-time.
- **Task 2: Hardware Proof:** Record the Windows Task Manager > Performance Tab > NPU graph spiking during usage. This is definitive proof for the AMD judges.
- **Task 3: Slide Deck:** Focus on the "Privacy-First" architecture and the "Psychology of Shopping."

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## 9. Conclusion

The "Emotion-Adaptive Shopping Interface" is a technically robust, socially relevant, and commercially viable project. By leveraging the **AMD Ryzen™ AI NPU**, the team transforms a privacy-invasive concept (webcam analysis) into a secure, edge-computing utility.

The project moves the hackathon entry beyond simple "automation" into the realm of **Empathic Computing**. It demonstrates a mastery of the full stack—from the silicon (NPU quantization) to the system (Native Messaging) to the user (React Overlay).

For the judges, the combination of **local inference efficiency**, **privacy-by-design**, and **tangible improvement to the shopping experience** makes this a top-tier contender. The roadmap provided here is ambitious but achievable for a dedicated team of three. The tools are ready; the hardware is capable. It is time to code the future of shopping.

# 10. Appendix: Technical Reference Guide

## A.1 Tech Stack Summary

| Component | Technology | Rationale |
|---|---|---|
| **Hardware** | AMD Ryzen 7040/8040 Series | NPU (XDNA) for efficient AI inference. |
| **AI Framework** | ONNX Runtime + Vitis AI EP | Standard deployment path for Ryzen AI. |
| **Quantization** | AMD Quark | Essential for NPU performance (Int8). |
| **Backend** | Python 3.10 | Native Messaging Host, Libraries availability. |
| **Frontend** | React + TypeScript | Component-based UI for the overlay. |
| **Styling** | Tailwind CSS | Scoped styling via Shadow DOM. |
| **Communication** | Chrome Native Messaging | Secure IPC between Extension and Python. |

## A.2 Troubleshooting the Native Bridge

- **Issue:** Python script starts but communication fails.
- **Fix:** Ensure stdout is in binary mode. sys.stdout.buffer.write() must be used. print() adds newlines and encoding that breaks the Chrome protocol.
- **Issue:** NPU not detected.
- **Fix:** Check vaip_config.json path in the Python script. Ensure the NPU driver (IPU) is visible in Device Manager.

## A.3 Privacy Policy Blueprint (for Hackathon)

- **Data Collection:** Video data is processed in Random Access Memory (RAM) only.

- **Data Retention:** No video data is written to disk or transmitted to the cloud.
- **Transparency:** A "Recording" indicator is always visible in the overlay when the AI is active.
- **Control:** User can toggle "Pause AI" globally or per site.

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