Building Out&Found

A web application to support missing & murdered 2SLGBTQIA* people

Building accurate forensic tooling requires a synthesis of cognitive psychology, biological morphology, and machine learning. To create a program that truly aids non-profits in the criminal justice sector, you must account for the inherent "noise" in human memory and the predictable yet complex patterns of craniofacial growth.

Methodologies

1. Forensic Sketching & Witness Reliability

The efficacy of a forensic sketch is less about the artist's "talent" and more about the **Cognitive Interview (CI)** process used to extract data.

Enhancing Memory Accuracy

- **The "Witness Artistic Rendition" Technique:** Recent studies (e.g., Eastwood et al., 2018) show that having a witness perform a rough sketch themselves before the formal interview increases the number of correct details recalled by 22%. This externalizes memory cues without the pressure of "getting it right" for a professional.
- **Encoding Specificity:** Recall is highest when the environment of the interview mimics the environment of the crime. Tooling should include "context reinstatement" prompts (e.g., asking about the weather, smells, or the witness's internal feelings at the time).
- **Avoiding the "Composite Effect":** Repeatedly looking at a poorly constructed composite can actually overwrite the witness's original memory. Tooling should prioritize "holistic" face construction (choosing whole faces that look similar) over "feature-based" construction (picking individual noses/eyes), as humans process faces holistically.

Specialist Insight: Lois Gibson, the world's most successful forensic artist, emphasizes "pulling the face" from the witness's soul rather than their words. Her manual, Forensic Art Essentials, is the industry standard for navigating the trauma-informed interview.

2. Age-Progression Methodology

Creating an accurate age progression—especially over a decade—requires more than just adding wrinkles; it requires a deep understanding of **craniofacial growth**.

Biological Growth Patterns

- **Children (Age 2–20):** The primary focus is the **forward and downward growth of the mandible** (lower jaw) and the lengthening of the nose. Before puberty, the face is rounder; during adolescence, the "adult" bone structure emerges.
- **Long-Term Progression (10+ Years):** For a 3-year-old missing for a decade, you must analyze the **biological heredity**. Most forensic artists use "Life-History" photos of parents and older siblings at the target age to predict specific traits, like the shape of the nasal bridge or the thickness of the lips.
- **The "Two-Year" Rule:** The *International Association for Identification* (IAI) recommends never attempting age progression on a child under two, and waiting at least two years between progressions for older children to allow for measurable skeletal change.

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3. Databases for AI Training

To build an accurate program, your model must be trained on **Longitudinal Face Databases.** These contain photos of the same individual over many years.

Database	Description	Best Use Case
FG-NET	1,002 images of 82 subjects (ages 0–69).	Best for **child-to-adult** progression training.
MORPH (Album 2)	55,134 images of 13,658 subjects.	Best for **adult aging** and ethnic diversity.
CACD	160,000+ images of celebrities over 10 years.	Best for "in-the-wild" (non-studio) lighting conditions.

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4. Engineering Considerations for Non-Profits

For a program to be useful to non-profits, it must handle **low-resolution "legacy" photos.**

- **Morphological Analysis Tooling:** Instead of a simple filter, the tool should allow for a "Morphological Overlay" where family traits (e.g., a father's heavy brow) can be layered onto the child's base structure.
- **Super-Resolution Pre-processing:** Use Generative Adversarial Networks (GANs) to upsample old, grainy photos from the early 2010s before applying aging algorithms.
- **Validation:** Incorporate a "blind test" module where the AI is asked to "de-age" a known adult back to their childhood photo to verify its accuracy.

Forensic Artist Lois Gibson's Technique

This video provides a deep dive into how Lois Gibson, the world's most successful forensic artist, uses witness memory to create sketches that have solved over 1,300 crimes.

The integration of these resources provides a significant leap in data quality, moving from general artistic principles to validated scientific datasets and peer-reviewed methodologies.

Integrating the groundbreaking research from the **University of Washington**, the visual anthropology of **Jan Langer**, and recent studies on **person memory**, we can define a blueprint for forensic tooling that moves beyond "artistic guesswork" into a data-driven science.

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5. Forensic Sketching: The "Holistic" Memory Protocol

Your tooling must prioritize how the human brain actually recalls faces. Research from *Science & Justice* and the *Doe Network* highlights that we do not remember faces as a collection of parts, but as a **global configuration.**

- **The Feature-Warping Paradox:** Standard "drag-and-drop" composite software (eyes + nose + mouth) often creates a "Frankenstein" effect that confuses the witness. Effective tooling should allow for **global warping**—adjusting the "vibe" or proportions of the whole face simultaneously.
- **The Confidence-Accuracy Trap:** A high-priority finding in witness reliability (Source 12) is that a witness's confidence in their sketch is a poor predictor of its accuracy.
    - *Implementation:* Tooling should include a **"Uncertainty Heatmap"** where witnesses can shade areas of the face they are less sure about, preventing the artist from "over-defining" incorrect features.

- **Cognitive Interviewing (CI):** The software should guide the interviewer through "Context Reinstatement"—asking the witness to visualize the lighting, weather, and their own emotional state before the first line is drawn.

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6. Age-Progression: The Biological & Digital Logic

For the 3-year-old abducted a decade ago, the challenge is that children undergo a **non-linear transformation** during puberty.

The University of Washington (UW) Breakthrough

The UW software (Source 5/6) changed the game by moving away from manual artistic "aging" to **Illumination-Aware Pixel Averaging.**

- **The Algorithm:** It computes "average image subspaces" from thousands of internet photos across every age bracket (0–80). It then calculates the **pixel-to-pixel shift** between brackets and applies that transformation to the child's photo.
- **Vertical Stretching:** Between ages 3 and 13, the primary change is the **vertical elongation of the mid-face.** The distance between the eyes and the upper lip increases as the maxilla (upper jaw) develops.
- **The "Milk Moustache" Resilience:** Modern tools must be "illumination-aware," meaning they can strip away the lighting and shadows of a grainy childhood photo to find the base facial structure before aging it.

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7. Ground Truth: Jan Langer's "Faces of Century"

Langer's work (Source 1/2) provides the "Long-Term Ground Truth" for your database. By pairing centenarians with their youth portraits, several consistent aging "constants" emerge:

- **The "Rooted" Nature:** Despite wrinkles and skin sagging, the **inter-ocular distance** (the space between the eyes) and the **basic geometry of the smile** remain remarkably stable over 80+ years.
- **Cartilage Expansion:** The ears and nose continue to grow throughout life, often becoming more prominent features in the 70+ year progression.
- **Identity Persistence:** Langer's project proves that while the "texture" changes, the "nature" of the face is rooted. A forensic tool should focus on preserving these **geometric constants** while layering the texture of time.

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8. The Scientific Guardrail: Recognition Interference

Crucially, your program must address the findings of **Lampinen et al.** (Source 11/12). Their research suggests that poorly executed age progressions can **actually harm investigations.**

> **The "Plausible Target" Problem:** An inaccurate age progression can lead the public to report hundreds of people who look like the *sketch*, but not the *person*. This clogs the investigative pipeline.

Proposed Safety Features for Non-Profit Tooling:

Feature	Scientific Basis	Benefit
Sibling-Similarity Weighting	Heredity Studies	Uses sibling photos at the target age to refine bone structure.
Multi-Path Output	Lampinen Paradox	Generates 3 versions (Thin, Average, Heavy) to account for weight variability.
Validation Module	"Blind" Testing	Allows the user to "de-age" a known adult to see if the AI can find their childhood photo.

Technical Data Integration

To build this, you should bridge the following databases:

1. **FG-NET / MORPH:** For child-to-adult growth trajectories.
2. **Faces Through Time:** For high-resolution longitudinal aging.
3. **Langer's Dataset:** For the 100-year extreme aging edge cases.

Forensic Theory

Here is a synthesis of the high-priority insights from these sources, structured for application in your forensic tooling project.

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9. Forensic Sketching: Cognitive Reliability & Evolution

The literature (specifically *Tactical Gear* and *Science & Justice*) highlights a transition from "artistic interpretation" to "cognitive science."

- **The "Sketch Artist" vs. "Composite" Debate:** While software like FACES or EFIT-V provides speed, studies in *Science & Justice* (Source 8/9) suggest that hand-drawn sketches—when guided by a specialist using **Cognitive Interviewing (CI)**—often outperform computer composites in "holistic" recognition.
- **The Holistic Advantage:** Human memory stores faces as global configurations rather than a list of parts (nose, eyes, lips). Successful tooling must prioritize **feature-warping** and **global-shaping** over a simple "drag-and-drop" library of features.
- **Witness Reliability Metrics:** Advanced reporting (Source 12) indicates that the *confidence* of a witness rarely correlates with *accuracy*. Tooling should include a "confidence-weighting" system for individual features during the sketching process.

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10. Age-Progression: Biological Logic & AI Training

The datasets and studies provided (Nature, Frontiers, Phys.org) establish the "ground truth" needed for your program.

Key Biological Drivers

- **The Craniofacial Growth Model:** Research from *Phys.org* (Source 11) discusses a "Face Aging" technique that uses a deep learning model to learn the specific trajectory of facial muscle and bone shift.
- **Childhood Progression (The 3-to-13 Year Gap):** For the case of the 3-year-old abducted a decade ago, the tool must account for the **vertical growth of the mid-face.**

Between ages 3 and 13, the distance between the eyes and the mouth increases significantly as the maxilla and mandible grow.
- **Heredity as a Predictor:** Specialists emphasize that for long-term missing children, "sibling-similarity" data is more accurate than generic aging algorithms.

High-Value Datasets

Your request for a database of photos over time is addressed by several of your sources:

- **The "Faces through Time" Dataset (Source 1/2):** The *Nature* and *Figshare* links provide access to validated, longitudinal images. This is the "gold standard" for training a neural network on how specific ethnicities and genders age differently.
- **AI-Generated Aging Repositories (Source 3):** The *s41597-025-05909-6.pdf* file you uploaded (Source 3) describes an open-access database of AI-generated faces representing individuals at young, middle, and old adulthood. This can be used to validate if your program can correctly identify the same individual across life stages.

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11. Data Comparison: Longitudinal vs. Generative

Source Type	Value to Your Tooling	Key Limitation
Longitudinal (Source 1, 13)	Ground truth of real human aging.	Limited sample size for specific ethnicities.
Generative (Source 3, 6)	Massive volume of training data.	Potential for "uncanny valley" or unrealistic bone structure.
Observational (Source 5, 12)	Real-world application and case studies.	Anecdotal; difficult to quantify for code.

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12. Addressing the 3-Year-Old Case

To accurately age-progress a 3-year-old child who has been missing for 10 years (now 13), your tool should follow the **Multi-Path Aging** strategy:

1. **Reference Point Alpha:** The original 3-year-old photo.

2. **Biological Reference:** Current photos of parents and siblings at age 13.
3. **Generative Interpolation:** Using the *FG-NET* or *Faces Through Time* data to apply the specific "growth curve" of a 10-year gap.
4. **Forensic Artist Overlay:** Manual refinement of "secondary traits" (e.g., likely hairstyles, dental shifts, or skin textures based on environmental factors).

Developing Accurate Forensic Sketching

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The following synthesis provides the scientific and data-driven framework necessary to develop accurate forensic sketching and age-progression tooling, incorporating the provided NCMEC datasets and academic research.

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17. Forensic Sketching & Witness Reliability

The accuracy of a forensic sketch is determined by the transition from "feature-based" to "holistic" construction.

- **The Holistic Advantage:** Human memory encodes faces as global configurations rather than a collection of individual parts. Software that allows for global face warping—adjusting width, jawline shape, and inter-ocular distance simultaneously—is more effective than libraries of individual eyes or noses.

- **Cognitive Interviewing (CI):** Tooling should include structured prompts for "context reinstatement," asking witnesses to visualize the environmental and emotional context of the crime before sketching.

- **Witness Uncertainty:** Reliability does not always correlate with confidence. Sketches should incorporate an "Uncertainty Heatmap," allowing witnesses to indicate which areas of the face are less clear in their memory to prevent over-defining incorrect features.

- **NCIC Integration:** 89% of long-term missing children cases are entered into the National Crime Information Center (NCIC), making digital compatibility with this database a requirement for effective recovery tools.

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18. Age-Progression Methodology

Accurate aging, especially over long durations (10+ years), requires biological logic based on craniofacial growth and heredity.

- **Biological Growth Constants:** Between ages 3 and 13, the primary skeletal change is the vertical elongation of the mid-face as the maxilla and mandible grow downward.
  +1

- **The Multi-Path Model:** Because lifestyle factors (weight, substance use) significantly impact aging, software should produce multiple variations (e.g., thin, average, and heavy versions).

- **Heredity Weighting:** Using "Life-History" photos of siblings or parents at the target age provides the most accurate bone structure for child progressions.
  +2

- **Validation Datasets:**
  - **Generative Repositories:** Use AI-generated datasets like the one described in *Scientific Data* (2025), which preserves identity across young adulthood, middle age, and older adulthood to train recognition algorithms.

  - **Longitudinal Photos:** Databases like "Faces Through Time" provide the ground truth for ethnic-specific aging patterns.

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19. Demographic-Specific Investigation Logic

Different populations exhibit distinct patterns of disappearance and recovery that should inform the "search logic" of the tooling.

Population	Key Recovery Data	Forensic Priority
Autism Spectrum	87% recovered in the same state; 98% recovery rate.	**High Risk:** 63% of deceased cases involved drowning. Search near bodies of water immediately.
Native American	80% go missing from state care; 99% recovery rate.	**Geography:** Shorter mean travel distance (57 miles). Focus on locations near tribal lands.
Online Enticement	36% recovered in a different state. +1	**Distance:** These victims travel much further than other missing peers (only 8% are typically interstate). +1
Family Abduction	90% abducted by biological parents; peak season is summer.	**Timeline:** Missing duration is declining (mean 2 months) but international cases last longer.

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20. Technical Architecture for Non-Profits

For a program to be effective for justice-sector non-profits, it should prioritize:

- **Low-Resolution Upsampling:** Use GAN-based super-resolution to process "legacy" childhood photos from the early 2000s or 2010s before applying aging algorithms. +1

- **Biometric Collection Support:** Forensic tools should facilitate the immediate collection of DNA, dental records, and fingerprints. Only 5% of long-term missing cases analyzed currently have DNA on file.

- **Mobile-First Alerts:** 180+ children have been recovered directly via Wireless Emergency Alerts (WEA). Tooling should include automated, geographically targeted social media and mobile alert generation.

To most accurately create forensic tooling for sketching and age progression—specifically designed for the criminal justice and non-profit sectors—the system must integrate cognitive psychology, craniofacial biology, and investigative data.

Below is the synthesized framework and functional requirements for this tooling, incorporating the latest research on missing persons, trauma-informed interviewing, and longitudinal growth.

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21. Forensic Sketching: The Trauma-Informed Cognitive Protocol

Sketching is not just an artistic task; it is a memory retrieval process. Tools must protect the integrity of the witness's memory while minimizing the "Frankenstein effect" of traditional composite software.

- **Trauma-Informed Cognitive Interviewing (CI):** The software should guide the artist through a structured CI protocol. This includes "Context Reinstatement," where the witness is prompted to recall the environment (sounds, smells, weather) and their emotional state to unlock "flashbulb" memories before any features are drawn.
- **Holistic Construction vs. Feature-Based Pickers:** Human memory stores faces as a "gestalt" or whole configuration. Tooling must allow for **global face-warping** (adjusting width, jawline, and eye-spacing simultaneously) rather than forcing a witness to choose an eye from a list, which can lead to "composite interference" (overwriting the real memory with the incorrect sketch).
- **Uncertainty Mapping:** Witnesses should be able to shade or "blur" areas of the sketch they are unsure about. This creates an **Uncertainty Heatmap**, preventing investigators from focusing on "over-rendered" features that might be inaccurate.

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22. Age-Progression: Biological and Lifestyle Logic

For children missing for a decade or more, the tool must account for the non-linear growth spurts of puberty and the vertical expansion of the skull.

- **Vertical Mid-Face Expansion:** Between ages 3 and 13, the primary skeletal change is

the downward and forward growth of the maxilla (upper jaw). The tool must apply a **vertical growth coefficient** that stretches the distance between the nose and the chin more aggressively than the width of the face.

- **Heredity-Weighting (The "Sibling Logic"):** The tool should allow for the upload of "Reference Points"—current photos of biological parents or older siblings at the target age. The AI then uses these as a "bone-structure template" to guide the progression of the missing child.
- **Cartilage Expansion:** For long-term progressions (20+ years), the software must simulate the continuous growth of the nose and ears, which do not stop expanding throughout the human lifespan.

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23. Functional Requirement: The Multi-Path Output System

Because lifestyle and environment significantly alter the aging process, a single "predicted" image is often a failure point. The tool should generate a **Triptych of Probability.**

Path Version	Biological Driver	Investigative Context
Path A: High-Stress / Substance	Accelerated skin aging, thinning hair, loss of facial volume.	Relevant for cases of trafficking or long-term homelessness.
Path B: Baseline / Health	Standard vertical skeletal growth, healthy skin elasticity.	Standard prediction for stable living environments.
Path C: High BMI / Weight Gain	Rounding of the jawline, softening of bone structure, neck expansion.	Accounts for the high variability in adolescent weight gain.

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24. Investigative Logic: Targeted Search Priorities

Data from NCMEC and the Department of Justice indicates that the "search logic" must change based on the victim's demographics.

- **The Autism Protocol:** If a child is on the autism spectrum, the tool should immediately trigger a "Water-First" search alert. Data shows that **63% of deceased cases involving**

children with autism were due to drowning.

- **The "36% Interstate" Rule:** For victims of online enticement, the tool must automatically expand the search beyond state lines. Unlike runaways (who usually stay within 50 miles), 36% of enticed children are recovered in a different state.
- **The "72-Hour Window" for AMBER Alerts:** Timeliness is the strongest predictor of recovery. The tool should include an "NCIC Fast-Track" module to ensure dental records, DNA markers, and the age-progressed image are entered into federal databases within the first 23 hours.

25. Biometric and Forensic Integration

To aid non-profits in the "Murdered and Unidentified" sector, the tool should serve as a hub for biometric data:

- **DNA and Dental Overlays:** Allow for the digital comparison of "Post-Mortem" sketches of remains with "Pre-Missing" childhood photos.
- **Super-Resolution Upsampling:** Use GANs to reconstruct low-resolution "legacy" photos (e.g., from old social media or flip-phones) into high-fidelity bases for aging.

26. Implementation Roadmap

To refine the development of forensic tooling from a project and operational standpoint, the system must transition from a standalone "art program" into a centralized **Forensic Investigative Hub**.

Based on the operational standards from APCO, NCMEC, and OJJDP, here is the technical roadmap for incorporating these resources into a functional forensic tool.

Phase 1: Intake & Metadata Standardization (APCO/NCIC Compliance)

The tool must ensure that data captured at the first point of contact (911/Dispatch) flows directly into the sketching and aging modules without loss of fidelity.

- **Standardized Case-Type Triage:** Integrating **APCO ANS 1.101.4-2022**, the tool should force-rank cases into specific categories (e.g., Endangered Runaway, Family Abduction, LIM). This dictates the **"Speed-to-Sketch" priority**.
- **Automated NCIC/Law Enforcement Exports:** Data fields must be mapped to ensure that a completed sketch or age progression is formatted for immediate entry into the **National Crime Information Center (NCIC)**. This reduces the 23-hour average lag time between a report and database entry.

Phase 2: Behavioral "Smart" Overlays for Sketching

Utilizing the **"Typical Abductor" profiles** (from the Infant and Family Abduction manuals), the tool can provide "Likely Trait" suggestions to artists during a witness interview.

- **Abductor Profile Logic:** If a case is flagged as an infant abduction, the tool can suggest features common to that demographic (e.g., female, childbearing age, specific manipulative facial expressions) to help nudge witness memory during a Cognitive Interview (CI).
- **The "Zone of Safety" Parameter:** For first responders, the tool should calculate a "Search Radius" based on the child's developmental stage. If the child is on the autism spectrum, the tool must immediately trigger **Water-Body Highlighting** on the local map, as 63% of deceased wandering cases involve drowning.

Phase 3: Dynamic Age Progression & Environmental Paths

For long-term cases, the tool must move beyond simple biological aging to account for the "Life Circumstances" of missing populations.

- **Path-Based Progression:**
  - **The Foster Care/Runaway Path:** Accelerated aging markers (stress-lines, potential substance-use effects) for children missing from child welfare services.
  - **The International Parental Abduction Path:** Highlighting traits that may be intentionally altered (hair dye, glasses) to facilitate border crossings.
- **Hereditary Anchoring:** The tool should allow for the digital "blending" of the child's base photo with current photos of biological parents to predict adult bone structure (Vertical Mid-Face Expansion).

Phase 4: Image Life-Cycle & Takedown Management

A critical gap in current tooling is what happens *after* a recovery. According to NCMEC's **Missing Child Poster standards**, outdated images can cause "digital trauma" and misinformation.

- **Automated Poster "Kill-Switch":** Once a child is marked as recovered, the tool should generate a **Digital Takedown Package**.
- **API-Driven Removal:** The tool should include a module that auto-submits "Outdated Content" removal requests to Google and social media platforms to scrub the child's missing poster and protect their privacy as they reintegrate.

Phase 5: Investigative "Heatmaps" for Search and Rescue

Integrating the **NLSARA Searcher Manual** and **Search Protocol Workbooks**, the tool should assist in the physical search logic.

Feature	Resource Basis	Functional Application
Searcher Competency Tracker	NLSARA 4.9	Assigns specific sketch/aging tasks based on the complexity of the "Human Factors" involved.
Probability of Detection (POD)	SAR Workbook	Overlays the sketch on a map of "high-probability" encounter points based on witness sightings.
Emergency Response Checklists	NCMEC Order #198	Auto-populates a "Quick-Reference" guide for the family as soon as a sketch is initiated.

Implementation Strategy

For non-profits, this tool should be **Open-Source but Secure**.

1. **Phase A:** Build the "Cognitive Sketch" module with uncertainty heatmaps.
2. **Phase B:** Integrate the "Biological Growth" aging algorithms.
3. **Phase C:** Deploy the "Life-Cycle Management" module for image removal.

Technical Software Framework

This technical framework is designed to bridge the gap between forensic science and scalable software, specifically for non-profits operating in the criminal justice sector. By integrating the biological growth logic, witness psychology, and behavioral data found in investigative standards, we can move from manual artistic processes to a data-driven identification engine.

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1. Technical Specification: "Right to be Forgotten" (RTBF) Takedown

API

Objective: Automate the removal of digital footprints (missing posters, age progressions) for recovered individuals to prevent secondary trauma and ensure safety.

- **API Type:** RESTful with Webhook support.
- **Authentication:** OAuth 2.0 (Mutual TLS for non-profit and platform handshake).
- **Endpoints:**
  - POST /v1/recovery-notification: Triggered when a case status is changed to "Recovered."
  - GET /v1/exposure-report: Scans 200+ partner APIs (Google Search, Meta, X, etc.) to generate a list of active URLs containing the child's image hash.
  - DELETE /v1/active-distribution: Submits a "Content Removal Request" via Google's "Remove Outdated Content" API and social media "Safety Takedown" channels.
- **Payload Requirements:** Image perceptual hash (pHash), NCMEC/NCIC Case ID, Recovery Date, and a cryptographically signed "Resolution Statement" from the reporting agency.

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2. Programming Specification: Forensic Age-Progression & Sketching Engine

This engine utilizes **Generative Adversarial Networks (GANs)**, specifically a modified **Identity-Preserving Aging GAN (IPA-GAN)**.

A. Longitudinal Heredity Module (Biological Aging)

Instead of a simple "aging filter," the code must implement a **Heredity-Aware Subspace**.

- **Logic:** The system ingests the "Child Baseline" (P_0) and "Biological Family Reference" (F_x).
- **Algorithm:** Calculate the "Vertical Growth Coefficient" (V_g) by comparing family members at age T_{target} vs. T_{young}.
- **Execution:** Apply V_g to the child's maxilla and mandible coordinates. Between ages 3 and 13, the script must force-stretch the mid-face by a factor derived from the family's bone-density and structure patterns.

B. Sketch-to-Life (S2L) Rendering

- **Input:** Hand-drawn forensic sketch or composite.
- **Processing:** A **StyleGAN3** encoder maps the sketch features into a latent space of high-resolution human faces.
- **Multi-Output Layer:** The generator produces a "Triptych of Probability" representing varied lifestyle paths:

1. **Baseline:** Healthy, standard development.
2. **Environmental Stress:** Thinned volume, skin texture changes (relevant for trafficking).
3. **High-BMI Path:** Softened jawline, increased neck circumference.

C. Craniofacial Reconstruction (3D Skull-to-Photo)

- **Forensic Depth Markers:** The system maps the skull (S) using 21 standard forensic landmarks (e.g., Nasion, Zygomatic, Menton).
- **Tissue-Depth Database:** Code assigns "Skin Thickness Coefficients" based on the age/sex/ethnicity data found in the *Scientific Data* repository.
- **Rendering:** A volumetric shader "shrink-wraps" a biological texture over the landmarks to provide a "Most Likely Alive" visualization.

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3. Technical Brief: Open Forensic Databases & APIs

To solve cold cases without traditional "on-the-ground" law enforcement access, the app must aggregate the following:

Database	Access Level	Utility for Non-Profits
NamUs API	Open / Public	Access to 24,000+ unidentified person records (height, weight, dental).
GEDmatch / FTDNA	Investigative	Forensic Investigative Genetic Genealogy (FIGG) for "John Doe" leads.
VI-CAP MO Records	Restricted (LE Partner)	Used to match "Signatures" (e.g., specific ligatures or ritualistic behaviors).
Google Maps Geodata	API	Spatial analysis of "Last Seen" locations vs. body recovery sites.

---

4. Implementation Plan: The Cold Case Resolution App

This application focuses on **Spatial-Temporal Pattern Recognition** to identify suspects and link crimes across borders.

Step 1: Data Normalization Engine

The app must "ingest" unstructured data (PDF news archives, scan-reports) and convert them into a structured **Crime-Signature JSON**.

- **Feature Extraction:** Auto-tags cases for "Overkill," "Signature Weapon," and "Geographic Proximity."

Step 2: The "Serial Pattern" Algorithm (Spatial Analysis)

- **Logic:** Perpetrators often have a "Comfort Zone" and a "Hunting Zone."
- **Function:** The app uses **Rossmo's Formula** for geographic profiling. It calculates the probability of a suspect's residence based on the cluster of "Last Seen" vs. "Body Recovery" coordinates.
- **Cold Case Linkage:** The engine scans cases in neighboring counties. If Case A (2012) and Case B (2018) share a "Landmark Proximity" (e.g., both within 1 mile of a specific trucking route) and "Signature," they are flagged for high-priority manual review.

Step 3: Collaborative OSINT (Open-Source Intelligence)

- **Feature:** A "Digital Evidence Vault" where users can upload public domain photos (e.g., yearbook photos, public social media) to be automatically aged and compared against current "Unidentified Remains" sketches in the database.
- **Suspect Identification:** By cross-referencing public property records and employment history (Source 34) with the "Geographic Profiling" results, the tool can narrow down potential suspects who lived or worked in the specific "high-probability" zones at the time of the crimes.

Step 4: Verification & Escalation

- **Confidence Scoring:** Every match is given a "Probabilistic Certainty Score."
- **Non-LE Workflow:** Once a match exceeds 85%, the non-profit can engage legal counsel (Source 36) to petition for DNA testing or private investigative follow-up, bypassing traditional jurisdictional hurdles.

Investigative Hub Framework

This technical framework transitions the "Forensic Investigative Hub" from a theoretical tool into a high-utility, validated application for the non-profit justice sector. By aggregating open-source intelligence (OSINT), forensic data, and geographic profiling, this system allows

organizations to investigate cold cases with professional-grade accuracy.

---

1. Multi-Source Validation & Aggregation Protocol

To ensure the system never relies on a single point of failure, we implement a **Validation Consensus Engine**.

- **Identity Cross-Referencing:** The system uses **Biometric Hash Matching**. When a sketch or photo is processed, the system generates a unique perceptual hash (pHash) and queries:
  - **NamUs / NCIC:** For official missing/unidentified records.
  - **Social Media Scrapers:** Using tools like *Snscrape* or *Social-Analyzer* to find profile photos with similar facial geometry.
  - **Educational Archives:** Automated crawling of publicly accessible "Wayback Machine" snapshots of school athletic pages (track, wrestling, etc.) to match historical height/weight metrics.
- **Real-Time Contextual Intel:** The UI integrates the **Google Search/Alerts API** to pull recent news articles, blog posts, and podcasts.
  - *Feature:* Every claim in the UI will include a **"Source Attribution Chip"** that links directly to the underlying URL, case file, or news report.

---

2. Technical Specification: Investigative "Entity" Cards

The application should surface information in a unified "Case Entity Card" that aggregates:

Data Type	Sourcing Method	Visible UI Component
Law Enforcement	OpenData APIs / Scraping	Agency Name, Unit (e.g., GBI Cold Case Office), Desk Phone, and direct Email.
Case Documents	Freedom of Information (FOI) Portal	Links to request Body Cam, Autopsy, or Case Reports.
The "Reward" Tracker	News/Non-Profit Scrapers	Amount (e.g., $10,000), Source (e.g.,

		CrimeStoppers), and Expiration Date.
Media & Journalism	RSS / Google News API	List of specific journalists and publications that have covered the case.
Local Support	Map-Based Proximity Query	Contact details for local PIs, search-and-rescue non-profits, or advocacy groups.

---

3. Python Pseudo-Code: Rossmo's Geographic Profiling

This script calculates the "Comfort Zone" (Probability Surface) of a perpetrator based on the locations of multiple crime scenes.

Python

```python
import numpy as np

def calculate_probability_surface(crime_locations, grid_size=(100, 100)):
    """
    Implements Rossmo's Formula: p(x,y) = sum [ k / (dist^h) ]
    where dist = Manhattan distance between grid point and crime site.
    """
    # 1. Define constants
    k = 1.0     # Scaling constant
    B = 0.5     # Buffer zone radius (distance where crime is less likely near home)
    h = 1.2     # Decay exponent (higher = steeper drop-off)
    g = 1.2     # Gravity constant for the buffer zone

    # 2. Create the search grid
    x_range = np.linspace(min_lat, max_lat, grid_size[0])
    y_range = np.linspace(min_lon, max_lon, grid_size[1])
```

```
    surface = np.zeros(grid_size)

    # 3. Iterate through every point on the map
    for i, x in enumerate(x_range):
        for j, y in enumerate(y_range):
            score = 0
            for crime in crime_locations:
                # Manhattan Distance calculation
                dist = abs(x - crime['lat']) + abs(y - crime['lon'])

                # Apply the distance decay function
                if dist > B:
                    # Standard decay: Probability drops as distance increases
                    score += k / (dist ** h)
                else:
                    # Buffer zone: Probability drops as you get TOO close to home
                    score += (k * (B**(g-h))) / ((2*B - dist)**g)

            surface[i, j] = score

    return surface # Result: A heatmap of the "Likely Anchor Point"
```

---

4. Technical Specification: User Submission Portal

To build a crowdsourced cold case database, the software requires a "Submission & Review" architecture.

- **The Intake Workflow:**
    1. **Submission:** User uploads photos, sketches, or case URLs.
    2. **Validation Check:** The system automatically checks if the case is already in the database using the pHash matching mentioned in Section 1.
    3. **Risk Triage:** If the submission contains sensitive/violent crime scene imagery, it is routed to a **Human-in-the-Loop (HITL)** queue for non-profit staff to review before public posting.
- **Submission API Endpoint:**
    - POST /v1/submit-case
    - *Required Fields:* victim_name, last_seen_location, baseline_photo, case_type, investigating_agency.
    - *Security:* Submissions are encrypted with AES-256; user metadata is anonymized to protect whistleblowers or family members.

5. Pattern Recognition & Serial Offender Logic

The software will automatically link cases across state lines by identifying "Signature Matches."

- **Cold Case Matching:** If a user submits a case in Georgia that shares a 90% "Signature Link" (e.g., specific ligature, location type, and victim profile) with an unsolved case in California, the system triggers a **"Cross-Jurisdictional Alert."**
- **Property/Tie Analysis:** Users can input "Known Suspect Anchors" (e.g., "Suspect X lived in this zip code in 1994"). The system then overlays these anchors on the **Geographic Profiling Heatmap** to see if they fall within the 95th percentile of the "Comfort Zone."

Tech Specifications (Investigative Hub)

This technical specification outlines the architecture for a comprehensive Forensic Investigative Hub, integrating biological modeling, automated digital footprint management, and multi-source data validation.

---

1. Technical Specification: Automated Poster Takedown API

To protect the privacy of recovered individuals, the system must automate the removal of "digital ghosts"—outdated missing posters and age progressions.

- **Architecture:** A microservice-based handler using **Perceptual Hashing (pHash)**.
- **The Workflow:**
    1. **Status Change:** Upon a "Recovered" status update in the local database, the system generates a pHash for all associated imagery.
    2. **Platform Handshake:** The API sends an authenticated request to the **Google Search Console "Remove Outdated Content"** tool and **Meta/X Law Enforcement Portals**.
    3. **Digital Scrubbing:** The service utilizes **Custom Search Engine (CSE) APIs** to identify cached URLs. It then auto-submits "Right to be Forgotten" (RTBF) requests citing NCMEC recovery protocols (File 30.pdf).
- **Endpoint Definition:** DELETE /v1/digital-footprint/{case_id}
    - *Input:* Case ID + Signed Resolution Affidavit.
    - *Output:* URL Exposure Report + Takedown Status Tracker.

---

2. Technical Specification: Forensic Rendering Engine

This engine uses a **Latent Diffusion Model (LDM)** with specific "Forensic Control Layers" to

ensure anatomical accuracy over artistic interpretation.

A. Heredity-Weighted Age Progression (Code Logic)

- **Input:** Subject Photo (P_{base}) + Sibling/Parent Photos at target age (F_{ref}).
- **Logic:** The script calculates a **Craniofacial Growth Vector** by mapping 68 facial landmarks on F_{ref}.
- **Implementation:** The code applies a "Vertical Growth Coefficient" to the mandible and maxilla. For a 10-year progression (e.g., age 3 to 13), the system stretches the mid-face by approximately 15–22%, mirroring vertical growth trends in biological datasets (File 11.pdf).

B. Sketch-to-Life (S2L) & Skull Reconstruction

- **Sketch-to-Photo:** Uses a **Pix2Pix HD** framework. It treats the sketch as a semantic map, where the AI "inpaints" realistic textures (skin, hair, iris) based on the witness's verbal descriptions of ethnicity and age.
- **Skull-to-Rendering:**
  1. **Landmark Mapping:** Ingests skull photos and applies the **21 Forensic Tissue Depth Markers** (Source 11).
  2. **Volumetric Shrink-Wrap:** The code generates a 3D mesh over the skull, assigning skin thickness based on the subject's projected BMI and demographic profile.

---

3. Technical Brief: Data Aggregation & Validation

A reliable system must cross-reference disparate data points to avoid the "single database" bias.

- **API Ingestion:**
  - **NamUs / NCIC:** Direct API hooks for unidentified remains and missing persons (Case ID, height, weight).
  - **Educational Scraping:** A module utilizing *BeautifulSoup* to query archived school athletic rosters. It matches a "John Doe's" unique features (height/weight/scars) against middle/high school track or wrestling data.
- **Investigative "Contextual" Surfacing:**
  - **LE Contact Discovery:** The app queries the **National Public Safety Bureau** database to pull direct contact details for state bureaus (e.g., GBI, CBI, Texas Rangers).
  - **Reward/Journalist Tracker:** Integrates **RSS feeds** and **Google Alerts** to aggregate "Reward for Information" announcements and identifies journalists specializing in cold cases through the *ProPublica* or *Marshall Project* author APIs.
- **Evidence Procurement:** Includes a pre-populated **FOIA (Freedom of Information Act)**

Template Generator for autopsy results, body cam footage, and case reports, tailored to the specific state's legal requirements (Source 36.pdf).

---

4. Implementation Plan: Cold Case Pattern Recognition

This module focuses on identifying serial patterns and "comfort zones" across jurisdictions.

A. Geographic Profiling (Rossmo's Formula)

The Python backend calculates a **Probability of Detection (POD)** surface. By clustering "Body Recovery" points versus "Last Seen" points, the system identifies the "Anchor Point"—the most likely area where the perpetrator resides or works.

B. The Cold Case "Signature" Linker

- **Mechanism:** Uses **Natural Language Processing (NLP)** to scan case files for "Signatures" (e.g., specific knot types, ritualistic staging, or geographic proximity to trucking routes).
- **Cold Case Matching:** If a new submission in one state shares a 75% "Signature Match" with an unsolved murder in another, the system triggers a **Multi-Jurisdictional Conflict Alert**.

---

5. User Submission & Review Architecture

To ensure the integrity of the data, the system follows a **Human-In-The-Loop (HITL)** intake process.

- **Intake Portal:** A secure mobile-responsive form where users submit:
  1. Case Details (Name, last seen, agency case number).
  2. Digital Evidence (Photos, sketches, or news links).
- **Review Pipeline:**
  - **Automated Tier:** Checks for duplicates via perceptual hashing.
  - **Human Tier:** Submissions are routed to a dashboard for non-profit investigators to verify against official LE records before being "Published" to the public-facing map.

This technical specification outlines the database architecture for **Out & Found**. To handle the complexity of forensic data, geographic profiling, and cross-jurisdictional pattern recognition, a **hybrid database approach** is required.

---

1. Architectural Overview

The system utilizes three primary data layers to ensure speed, relational integrity, and pattern

discovery:

- **Relational Layer (PostgreSQL):** Core case management, user data, and agency contacts.
- **Graph Layer (Neo4j):** Mapping "Signatures" and "Anchor Points" to identify serial patterns across borders.
- **Vector/Search Layer (OpenSearch):** High-speed matching of biometric descriptions and NLP-based case linking.

---

2. Core Schema Definitions (PostgreSQL)

Table: Cases

The central entity for every missing or unidentified person.

- case_id: UUID (Primary Key)
- status: Enum (Active, Cold, Recovered, Unidentified)
- identity_type: Enum (Identified, John_Doe, Jane_Doe)
- full_name: String (Nullable for Does)
- phash_id: String (Perceptual hash of the primary reference photo)
- vertical_growth_coef: Float (Calculated biological growth multiplier)
- source_attribution_map: JSONB (Maps every field to its validated source_id)

Table: Forensic_Assets

Stores metadata for sketches and age progressions.

- asset_id: UUID
- case_id: UUID (Foreign Key)
- asset_type: Enum (Original, Sketch, Age_Progression, 3D_Reconstruction)
- storage_url: String (S3 path)
- uncertainty_map_url: String (Path to the witness uncertainty heatmap overlay)
- creation_metadata: JSONB (AI model version, seed, and family reference weights used)

Table: Geographic_Nodes

Feeds the Rossmo Geographic Profiling algorithm.

- node_id: UUID
- case_id: UUID
- node_type: Enum (Last_Seen, Body_Recovery, Sighting, Suspect_Anchor)
- coordinates: Point (Lat/Long)
- timestamp: DateTime
- accuracy_radius: Integer (Meters)

---

3. Pattern Recognition Schema (Neo4j Graph)

To identify "serial patterns," the system must link cases based on **Behavioral Signatures** rather than just names.

Nodes:

- Case: Represented by case_id.
- Signature: Specific MO (e.g., "Specific_Ligature", "Proximity_to_I95", "Ritualistic_Staging").
- Suspect: Potential anchor points or identified individuals.

Relationships:

- (:Case)-[:EXHIBITS]->(:Signature): Links cases with identical crime scene "signatures."
- (:Case)-[:GEOGRAPHIC_OVERLAP {probability: float}]->(:Case): Automatically generated when Rossmo's "Comfort Zones" intersect across state lines.

---

4. Validation & Attribution Schema

Ensures the "Consensus-First" requirement is met by tracking the origin of all intel.

Table: Data_Sources

- source_id: UUID
- source_name: String (e.g., "NamUs API", "Social Media Archive", "GBI Public Portal")
- source_url: String
- verification_level: Integer (1-5, where 5 is a verified federal database)
- last_synced: DateTime

---

5. Automated Poster Takedown Logic (State Management)

To manage the digital footprint post-recovery, the database tracks the "Life-Cycle" of imagery.

Table: Image_Distribution_Log

- log_id: UUID
- asset_id: UUID
- platform: String (e.g., "Google_Search", "Facebook", "X")
- external_url: String
- takedown_status: Enum (Active, Request_Sent, Scrubbed)

- resolution_affidavit_url: String (Proof of recovery submitted to the platform)

---

6. Security & Privacy Constraints

Given the 2SLGBTQIA+ focus, the database must implement **Row-Level Security (RLS)**:

- **Encryption:** All PII (Personally Identifiable Information) and sensitive crime scene imagery must be encrypted at rest using AES-256.
- **Trafficking Flag:** Cases marked as "High Risk - Trafficking" are restricted from public search results and are only visible to verified Non-Profit staff until the HITL (Human-In-The-Loop) review is complete.
- **Anonymization:** User submission metadata (IPs, uploader identity) is separated from the case data to protect whistleblowers and family members.

---

7. Investigative Query Examples

Rossmo Algorithm Input Query:

SQL

```
SELECT coordinates, node_type
FROM Geographic_Nodes
WHERE case_id = [UUID]
ORDER BY timestamp ASC;
```

Cross-Jurisdictional Signature Match (Cypher/Neo4j):

Cypher

```
MATCH (c1:Case)-[:EXHIBITS]->(s:Signature)<-[:EXHIBITS]-(c2:Case)
WHERE c1.state <> c2.state
RETURN c1, c2, s;
```

Biometric Validation Query (OpenSearch):

JSON

```
{
  "query": {
    "bool": {
      "must": [
        { "match": { "height_cm": 175 } },
        { "match": { "weight_kg": 70 } },
        { "match": { "tags": "track_and_field" } }
      ]
    }
  }
}
```

This database architecture provides the structural foundation to ensure **Out & Found** is not just a repository, but a proactive engine for justice.

To account for the "jurisdictional leakage" often exploited by perpetrators to evade detection, **Out & Found** will implement a **Cross-Jurisdictional Sweep (CJS)** as a core logic gate. This ensures that the search parameters are not artificially constrained by political borders which do not reflect the physical reality of a victim's or perpetrator's movement.

The following technical and operational logic will be integrated into the system to automate this "border-blind" investigation:

8. The "36% Interstate" Logic Gate

Data from NCMEC (File 4.pdf) indicates that for certain case types—specifically online enticement and non-family abductions—up to **36% of victims are recovered in a different state** than where they went missing.

- **Technical Implementation:** When a case is tagged as "High Risk for Movement" (e.g., Online Enticement, Trafficking, or Suspected Serial Pattern), the system automatically defaults the **Geographic Search Radius** to a "Regional" tier rather than a "Local" tier.
- **The Buffer Zone:** The search logic will automatically ingest data from all **Contiguous Jurisdictions** within a 300-mile radius, regardless of state lines.

9. Rossmo Algorithm: Border-Effect Weighting

Perpetrators often seek out "legal dead zones" at the intersection of county or state lines, assuming that local law enforcement agencies (LEAs) rarely share real-time data across borders.

- **The Logic:** The Rossmo's Geographic Profiling script will be updated to include a "Boundary Weighting Coefficient." * Pseudo-code Update: ```python
  Calculate Cross-Border Probability
  if node_type == "Last_Seen" and dist_to_state_line < 50_km:
  # Increase the search weight in the neighboring state
  border_leakage_weight = 1.5
  surface[neighboring_state_grid] *= border_leakage_weight
- **Why it works:** This forces the heatmap to account for the high probability that a perpetrator used a highway corridor to dump evidence or transport a victim across a state line within the first 2-4 hours of the crime.

10. Automated "Border Bureau" Notifications

The **Case Entity Card** will feature a dynamic "Regional Authority" section.

- **Multi-State Contact Mapping:** If a person goes missing in **Atlanta, GA**, the system identifies that the location is within a 2-hour drive of both the **Alabama** and **South Carolina** borders.
- **The Output:** The UI will automatically surface contact details not only for the GBI (Georgia Bureau of Investigation) but also for the **Alabama Law Enforcement Agency (ALEA)** and the **SLED (South Carolina Law Enforcement Division)**.
- **API Validation:** The system will concurrently query NamUs and NCIC records for all three states to check for "John/Jane Doe" entries with matching height/weight/biometric markers within a 7-day window of the missing date.

11. Pattern Recognition Across State Lines

The **Cross-Jurisdictional Signature Matcher** (Neo4j Graph Layer) will specifically hunt for "Traveling Offender" markers.

- **Corridor Analysis:** The system maps cases against major interstate corridors (e.g., I-95, I-10, I-80).
- **The Linker:** If a signature in **Raleigh, NC** matches a signature in **Richmond, VA**, the graph database creates a "High-Probability Link" relationship.
- **Validation:** It then cross-references public property and employment records to see if any suspects in the database have residential or work history ("Anchors") in both cities.

12. Managing "Legal Confusion" in Recovery

To prevent law enforcement from being "confused" or stalled by jurisdictional hurdles:

- **The FOIA Engine:** The app provides pre-filled **Inter-State Information Request** templates. These are tailored to the specific public record laws of the surrounding states, ensuring non-profits can legally demand data from a neighboring jurisdiction that may not yet be aware their case is part of a larger regional pattern.
- **Hague Convention Readiness:** For cases nearing international borders (File 31.pdf), the tool triggers a "Border Watch" protocol, surfacing the specific legal requirements for preventing a child or victim from being moved out of the country entirely.

By implementing this regional-first logic, **Out & Found** ensures that the "Chosen Family" is not just looking in their own backyard, but is actively monitoring the entire geographic network where a loved one may have been taken.