| **Feature** | **SHA Hashing** | **GAN-based Signature** |
| --- | --- | --- |
| Reversible | ❌ No | ❌ No |
| Tolerates input variability | ❌ No | ✅ Yes |
| Learns identity patterns | ❌ No | ✅ Yes |
| Can match across time/expressions | ❌ No | ✅ Yes |
| Privacy-preserving | ❌ Not by design | ✅ Core feature |
| Regulatory compliant | ❌ Risky for biometrics | ✅ Designed for GDPR/CCPA |

SHA is irreversible, yes—but not intelligent. It cannot tolerate the natural variability of human faces, nor can it match across sessions. GANs, on the other hand, generate non-reversible yet identity-consistent signatures, making them the only viable choice for real-time, privacy-compliant facial authentication.

**Why GAN Wins**

**Best for Privacy & Regulation**

* GAN discards image data and only keeps abstract, *non-reversible* face features.
* Others either store image-like data or embeddings that can be traced back.

**Best for Matching with Variability**

* SHA needs perfect match.
* AE/PCA break under different expressions/lighting.
* GANs handle real-world variability like glasses, smiles, aging.

**Best for Real-Time Edge Authentication**

* GAN inference can run on local GPUs — fast and compliant.
* AE/FaceNet also fast, but not privacy-first.

"Other methods either fail to match faces across sessions or can be reverse-engineered. GANs give us the rare ability to create **non-reconstructable, yet consistent facial signatures**. They’re secure, fast, privacy-first, and regulation-compliant—making them the only viable option for safe biometric authentication in financial centers."

| **Metric** | **GAN (Your Method)** | **SHA Hashing** | **Autoencoders (AE/VAE)** | **FaceNet / CNN Embeddings** | **PCA / LDA** |
| --- | --- | --- | --- | --- | --- |
| **Reversible?** | No — GAN intentionally discards reconstructive features. | ❌ No — irreversible, but input guessing is possible. | ✅ Yes — can regenerate face images. | ❌ No — but can be inverted via optimization attacks. | ✅ Yes — linear algebra allows reversal. |
| **Handles facial variation?** | ✅ Yes — trained on diverse data to tolerate pose, light, and expression changes. | ❌ No — even tiny change gives totally different hash. | ❌ No — poor performance on unseen variations. | ✅ Yes — embeddings remain similar across variations. | ❌ No — very sensitive to lighting and pose. |
| **Privacy-preserving?** | ✅ Yes — produces non-reversible, anonymized vectors only. | ❌ No — hashes of biometrics still represent raw data risk. | ❌ No — latent codes can reconstruct face images. | ❌ No — embeddings can be exploited to recreate facial features. | ❌ No — linear features can leak identity. |
| **Can match across sessions?** | ✅ Yes — generates similar signature each time for same person. | ❌ No — every minor change results in a different hash. | ❌ No — signatures change if inputs aren’t identical. | ✅ Yes — produces consistent embeddings. | ❌ No — lacks repeatability under real-world variations. |
| **Edge deployable?** | ✅ Yes — optimized for real-time use on GPU-enabled local devices. | ✅ Yes — lightweight, but lacks biometric utility. | ❌ No — inference and reconstruction are slow. | ✅ Yes — real-time on mobile and edge hardware. | ✅ Yes — lightweight, but not suitable for secure auth. |
| **GDPR/CCPA compliant?** | ✅ Yes — no biometric image or template stored. | ❌ No — hashed biometrics may still be classified as sensitive PII. | ❌ No — stores reconstructable image codes. | ❌ No — identity risk if embeddings are compromised. | ❌ No — lacks privacy-preserving properties. |
| **Self-adaptive over time?** | ✅ Yes — refines signatures subtly with changing appearance. | ❌ No — static and brittle to change. | ❌ No — no update mechanism for aging or expression change. | ✅ Yes — can retrain or refresh embeddings periodically. | ❌ No — doesn't adapt to individual over time. |

Source:

<https://dl.acm.org/doi/10.1145/3641107>

<https://arxiv.org/abs/2305.02143>

<https://arxiv.org/abs/2104.11721>

<https://www.researchgate.net/publication/360626999_Graph-Based_Generative_Face_Anonymisation_with_Pose_Preservation>

<https://arxiv.org/abs/2104.11721>