



AI-Based Detection of Spurious Gold in Gold-Loan Origination and Custody

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Abstract: Gold loans occupy an unusual position in a bank's secured-lending book: the collateral is fungible, easily disguised, and valued by a human being in a matter of minutes. Every other form of collateral in a bank's book – property, vehicles, securities – has a documentary trail that can be independently verified after the fact. A gold ornament, once sealed into a tamper-evident packet, is largely opaque until the loan is closed or the account turns delinquent and the packet is opened for auction. This asymmetry is precisely what spurious-gold fraud exploits: if the purity or the physical presence of the metal is misrepresented at the point of valuation, or substituted afterward while in the bank's custody, the loss is not discovered until years later, at a stage where recovery is close to impossible.

Key Words: Spurious gold; Gold loans; Artificial intelligence; Computer vision; Karat estimation; Photogrammetry; Density estimation; Custody assurance.

I. INTRODUCTION

Gold loans occupy an unusual position in a bank's secured-lending book: the collateral is fungible, easily disguised, and valued by a human being in a matter of minutes. Every other form of collateral in a bank's book – property, vehicles, securities – has a documentary trail that can be independently verified after the fact. A gold ornament, once sealed into a tamper-evident packet, is largely opaque until the loan is closed or the account turns delinquent and the packet is opened for auction. This asymmetry is precisely what spurious-gold fraud exploits: if the purity or the physical presence of the metal is misrepresented at the point of valuation, or substituted afterward while in the bank's custody, the loss is not discovered until years later, at a stage where recovery is close to impossible.

This paper proposes a solution built around a single, deliberately narrow design constraint: every check must be performable from an ordinary photograph, taken at the branch, with no acid, no water bath, no ultrasonic probe and no round-trip to a specialised laboratory. The justification for this constraint is operational rather than technical – a solution that needs new hardware, consumables or a trained technician at every branch will not scale to a network of thousands of branches, whereas a photograph-only pipeline can run on the same handheld device the valuer already uses, and can be logged, timestamped and audited like any other digital record.

II. PROBLEM STATEMENT

A gold loan transaction has four principal actors: the customer who pledges the ornament, the empanelled valuer who assesses its purity and weight, the bank official (banker) who disburses against that assessment and takes the packet into custody, and the loan and core-banking system that records the transaction and holds the packet in the double-lock vault for the tenure of the loan. Fraud can be introduced by any one of these actors acting alone, or by collusion between two or more of them, and it can be introduced either at origination (the ornament pledged is not what it is declared to be) or during custody (the ornament pledged is genuine, but is subsequently tampered with, substituted or removed while in the bank's keeping).

The table below sets out the resulting scenarios as a simple truth table over three binary questions – is the ornament genuine, is the declared weight and purity accurate, and does the sealed packet remain tamper-free for the full tenure of the loan.

Table 1. Truth table of gold-loan fraud scenarios across the four actors.

Field experience and internal loss analysis both point to Case 2 – spurious gold passed off as genuine at the point of valuation – as the dominant source of loss by value, principally through two mechanisms: amalgamation, where gold is alloyed with cheaper metals in a way that is difficult to detect visually, and gold-plating or gold-coating over a silver or copper core, where only a thin surface layer is genuine. Case 3 – insider substitution or removal of a genuine, correctly valued packet while it sits in the vault – is lower in frequency but disproportionately severe when it occurs, because it implicates an employee of the bank rather than an external counterparty.

Scenario	Ornament genuine?	Weight/purity as declared?	Packet tamper-free through tenure?	Loss exposure
Case 1	Yes	Yes	Yes	Nil
Case 2	No (amalgam / plated core)	Overstated at entry	Yes	High – valuer miss at origination
Case 3	Yes	Yes at entry	No – substituted/removed in custody	High – insider risk
Case 4	No	Overstated	No	Compound – collusive

Table 1. Truth table of gold-loan fraud scenarios across the four actors.

III. LIMITATIONS OF EXISTING DETECTION METHODS

The touchstone and nitric-acid test remains the industry default for on-the-spot purity checking. It is fast and inexpensive, but it is destructive to a small streak of the ornament, its result is read by eye against a colour chart and is therefore subject to the individual valuer's judgement and lighting conditions, and it says nothing about the interior of the piece – a thick gold-plated shell over a base-metal core can pass a surface acid test entirely.

X-ray fluorescence (XRF) analysers give a much more reliable elemental reading but are expensive, require calibration and maintenance, and are typically limited to a handful of larger branches or central valuation hubs, which reintroduces the delay and logistics that the loan product is designed to avoid. Ultrasonic thickness and density probes can, in principle, detect a plated core, but again require dedicated hardware and a trained operator at every counter. Water-displacement density testing is simple in concept but slow, requires a controlled setup, and is awkward to standardise across a network where branches vary widely in physical infrastructure.

None of these methods addresses Case 3 at all – they are all origination-time checks. A packet that passed every purity test at the counter provides no protection once it is inside the vault, because the existing control there is essentially procedural: a double-lock mechanism requiring two officials to be present, supported by periodic physical audits. Between audits, a packet's continued presence and integrity is effectively unverified.

IV. PROPOSED SOLUTION ARCHITECTURE

The proposed system has two stages that mirror the two failure points identified above: an origination-time imaging pipeline that estimates karat, volume and density from photographs, and a custody-time monitoring layer that continuously verifies the physical presence of pledged packets against the core banking system. Both stages are described in turn.

4.1 Karat Estimation from Colour, Luminosity and Reflectance

The karat-estimation model is a convolutional neural network trained directly on photographs of jewellery rather than on any extracted colour swatch, so that surface texture, engraving and wear are part of the learned representation rather than noise to be pre-processed away. The network is trained to place a piece into one of three purity bands – below 20 karat, 20 to 22 karat, and above 22 karat – and additionally to regress a specific karat value, since a coarse band alone is not sufficient for loan-to-value calculation.

The model exposes two operating modes. A learn mode takes a photograph together with a ground-truth karat value (established through an independent reference test during model-building, not in production) and updates the model; a test mode takes only a photograph and returns a predicted karat number together with a confidence interval computed at 90, 95 and 99 percent confidence. Presenting a confidence band rather than a single point estimate is a deliberate design choice: it allows a valuer-facing application to route low-confidence cases – heavily engraved pieces, unusual alloys, poor lighting – to manual second review, rather than silently returning an unreliable number with false precision.

4.2 Volume Estimation by Single-Photograph Photogrammetry

Karat estimation alone cannot catch a plated base-metal core, because the surface the camera sees is genuine gold; it is the interior that is not. The system therefore separately estimates the ornament's volume and, from that, its density, since a plated core will have a density markedly different from solid gold of the declared karat even when the surface colour is correct.

Volume is recovered from a single photograph rather than from water displacement, using two low-cost physical aids placed alongside the ornament at the time of photography: a sheet of graph paper as a calibrated backdrop, from which the ornament's footprint area is measured directly against the known grid spacing, and a mirror angled at 45 degrees behind the piece, which gives the same photograph a simultaneous side-on view from which height is measured. Area from the graph paper and height from the mirror reflection together yield an estimate of volume using classical computer-vision geometry; the convolutional network is used only for the karat classification, not for the geometric measurement, which keeps the volume estimate interpretable and auditable rather than a further black-box output. An earlier design that estimated height

from the shadow cast by a vertical pin was found to be workable but visually crude for a customer-facing process and was set aside in favour of the mirror method once it was confirmed to deliver comparable accuracy to the graph-paper area measurement.

Volume and the CNN-estimated karat together give an expected weight for a solid piece of that purity. Net weight is captured independently at the counter as it is today. A material shortfall between expected and actual weight, for a given estimated volume, is the signature of a hollow casting or a lighter-than-gold core, and is flagged for manual review rather than acted on automatically.

4.3 Why a Magnet Test Is Not Required

A magnetic-core check was evaluated and deliberately excluded from the design. Ferromagnetic cores used in the cheapest counterfeits are light enough that they are already caught by the density comparison in Section 4.2; adding a magnet test would provide no additional coverage against the fraud patterns actually seen in the portfolio, while adding a step to the customer-facing process. The design principle followed throughout is to prefer field tests that require no water, no electricity and no audible equipment, since these are the tests most likely to be performable identically at a metropolitan branch and a rural single-officer branch.

4.4 Custody Assurance: Continuous Imaging of the Double-Lock Area

The second half of the framework addresses Case 3 – substitution or removal of a genuine, correctly valued packet while it is in the bank's custody. The core banking and loan asset processing system already records when a loan is opened and, implicitly, that the corresponding packet should be either inside the double-lock vault or in front of the valuer's camera during a permitted retrieval. The proposal is to make that implicit expectation an explicit, continuously monitored one: a low-cost camera fixed on the double-lock storage area and on the designated valuation position, running an image-baseline comparison against a reference photograph taken when each packet was sealed, with the result cross-checked against the core banking system so that routine, authorised movements do not generate false alerts.

Two operational rules follow from this design. First, whenever a loan account shows as open in the core banking system, the corresponding packet must be verifiably either in the locker or visible on the valuer's camera at the designated position – an account that is open with no packet visible anywhere is itself the alert condition, rather than requiring the system to recognise a specific tampering pattern. Second, if a packet is away from the vault – for instance during a scheduled audit or a customer part-release – for more than a defined threshold, proposed at thirty minutes, an alert is raised to all staff at the branch rather than to a single individual, which removes the possibility of a lone insider intercepting and suppressing the alert.

4.5 Residual Risk: Insider Behaviour and Distress Signals

Imaging and system cross-checks reduce but do not eliminate insider risk, because a sufficiently well-placed insider with legitimate access can, in principle, defeat a static control if given enough time and enough trust. The framework therefore also proposes a behavioural layer, applied to customers, valuers and bankers alike, that looks for patterns rather than single events – repeated after-hours access to the vault by the same individual, valuation timings that are statistical outliers, or a pattern of loans concentrated on one valuer's assessments that later show discrepancies at closure. For valuers and custodian staff specifically, a distress-signal screening process is proposed as an extended-watch trigger rather than an accusation – signals such as a sudden rise in personal borrowing, or indicators of gambling or betting activity, are used only to place an individual under closer, unannounced audit rotation, consistent with how banks already handle other high-trust roles.

V.SYSTEM WORKFLOW

At origination, the branch officer photographs the ornament once, with the graph-paper backdrop and mirror in place, using the same handheld device used for existing loan documentation. The karat model and the volume pipeline run against that single photograph; net weight is entered as today. The system returns an estimated karat with confidence band, an estimated volume and density, and an expected-versus-actual weight comparison, and either clears the packet for normal processing or routes it to manual second valuation when confidence is low or the density check is inconsistent with the claimed purity. The packet is then sealed, photographed as the custody baseline, and placed in the double-lock vault, at which point the custody-monitoring layer in Section 4.4 takes over for the remaining life of the loan.

VI.ILLUSTRATIVE COST-BENEFIT ANALYSIS

The following figures are indicative, drawn from a portfolio of approximately Rs 1.5 lakh crore at an average ticket size of roughly Rs 20,000, and an assumed empanelled-valuer cost of roughly Rs 300 per packet valuation. They are intended to size the opportunity rather than to serve as a budget estimate.

Table 2. Indicative comparison of manual and AI-assisted valuation, current portfolio scale.

The saving is best read as a reduction in recurring per-packet valuer cost across the lifetime of the portfolio, rather than a one-time figure; it excludes, and is additional to, the harder-to-quantify avoided loss from fraud that is caught earlier or deterred outright by continuous monitoring.

Parameter	Manual valuation	AI-assisted valuation
Cost per packet (empanelled valuer fee)	≈ Rs 300	Near-zero marginal cost after deployment
Time per valuation	8–15 minutes, dependent on valuer availability	Under a minute, photograph-driven
Consistency across branches	Varies with individual valuer skill and integrity	Uniform model output, auditable
Estimated portfolio-lifetime saving*	–	≈ Rs 4,500 crore across an indicative Rs 1.5 lakh crore book at ~20,000 average ticket size

Table 2. Indicative comparison of manual and AI-assisted valuation, current portfolio scale.

VIII.LIMITATIONS AND FUTURE WORK

The framework is deliberately imaging-only, and this is both its principal strength and its principal limitation. A sufficiently sophisticated alloy engineered to match both the surface colour and the bulk density of genuine gold would not be caught by either the karat model or the volume pipeline; such adulteration is rare and expensive to produce, but not impossible, which is why the design routes low-confidence and inconsistent cases to manual review rather than fully automating the accept/reject decision. Camera coverage of the vault is similarly a deterrent and detection layer, not a physical barrier, and remains dependent on the integrity of the video pipeline itself, which should be protected with the same access controls and tamper-evidence applied to any other security camera system. Future work includes building out a larger, purity-labelled training set across the range of alloys and finishes seen in the portfolio, validating the volume pipeline's accuracy against XRF and water-displacement ground truth across a representative branch sample before any production rollout, and extending the confidence-band approach used for karat estimation to the density and expected-weight checks as well.

VIII.CONCLUSION

Spurious gold in loan origination and insider substitution in custody are two distinct failure modes that share a common weakness in current practice: both rely on a single, unaudited, point-in-time human judgement. Replacing the origination judgement with a photograph-based, confidence-scored model, and replacing the custody assumption with continuous, cross-checked imaging, does not remove the human valuer or the human custodian from the process, but it does give the bank a contemporaneous, auditable record against which both can be checked. The approach is designed to be deployable with equipment already at or cheaply added to every branch – a camera, a sheet of graph paper, a small mirror – which is the condition on which any control of this kind can realistically scale across a large branch network.

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