Automating Narcotic Waste Measurement and Drug Verification for Returned PCA Bags

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Background/Problem

Controlled substances such as morphine, hydromorphone, and fentanyl are high risk, and returned PCA bags are a diversion concern because they can contain residual clear liquid that cannot be confirmed by sight alone. About 10% of healthcare workers ay divert opioids and other substances during their career making controlled substance handling a major safety concern [1].

Clinical Need

The pharmacy department need a fast, automated way to verify the identity of residual narcotics in returned PCA bags because visual checks and manual witnessing alone cannot reliably detect substitution or confirm what drug is left.

Mission Statement

We strive to reduce drug diversion and improve hospital safety through automated verification of returned PCA bag contents.

Methods

- Prototype Design
  - Developed a bench top concept for returned PCA bag verification
  - Included a scanner, docking tray, and UV-Vis testing chamber
- Sample Testing
  - Tested liquid samples of morphine, hydromorphone, and fentanyl
  - Measured how each sample absorbed light
- Data Analysis
  - Compared each sample to known drug patterns
  - Labeled results as Match or No Match

Analytical Basis

Beer–Lambert Law

A = εbc

A = absorbance

ε = molar absorptivity

b = optical path length

c = concentration

Decision Rule

Similarity ≥ 0.80 → Match

0.65–0.79 → Retest

< 0.65 → No Match

Prototype Design

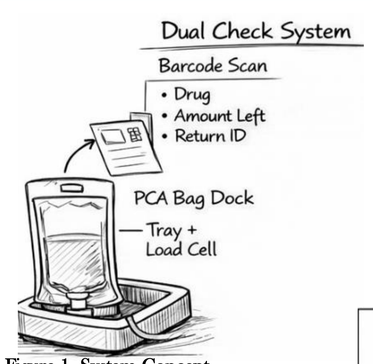

Figure 1. System Concept
Tray design used to position the PCA Bag and support weight-based measurement .

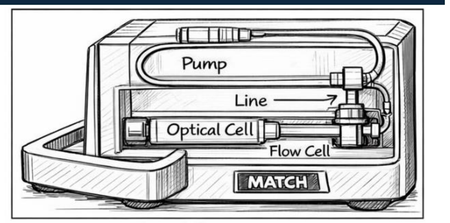

Figure 2. System Concept
Returned PCA bag is scanned, docked, and verified inside the benchtop unit.

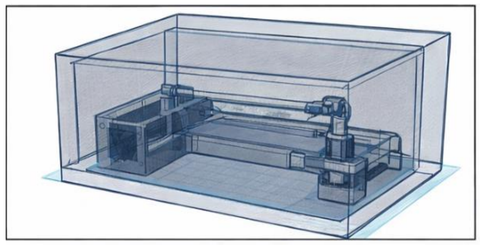

Figure 3. Internal layout
Transparent CAD view showing the pump, tubing path, optical cell, and flow cell.

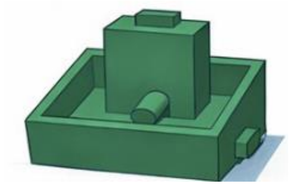

Figure 4. Docking Tray
Tray design used to position the PCA bag and support weight-based measurement.

Results

Simulated proof of concept results suggests the prototype could separate morphine, hydromorphone, fentanyl, and saline using a micro sample UV-Vis screening approach.

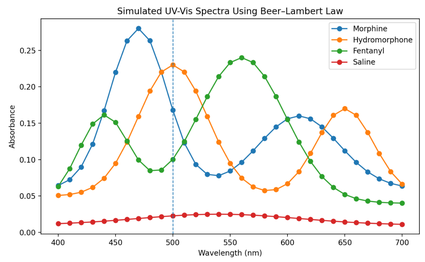

Figure 5. Simulated UV-Vis Spectra
Curves from 400-700 nm show visible separation among morphine, hydromorphone, fentanyl, and saline.

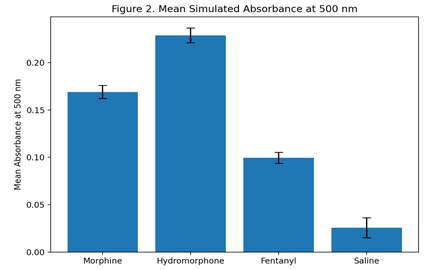

Figure 6. Mean Absorbance at 500 nm
Mean simulated absorbance at 500 nm for morphine, hydromorphone, fentanyl, and saline with standard deviation error bars.

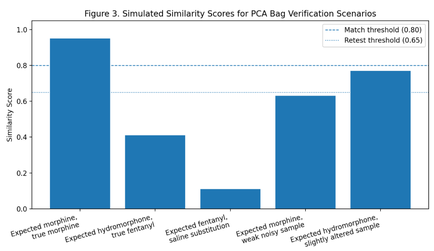

Figure 7. Similarity Score Thresholds
Decision threshold were set at ≥0.80 for Match, 0.65–0.79 for Retest, and <0.65 for No Match.

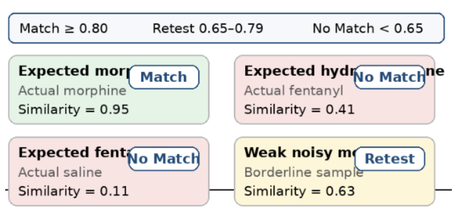

Figure 8. Simulated Device Outputs
Simulated cases showed Match for correct samples, No Match for clear mismatches, and Retest for borderline cases.

Discussion

Simulated results support the feasibility of micro-sample UV-Vis screening for returned PCA bag verification. Absorbance at 500 nm differed significantly across morphine, hydromorphone, fentanyl, and saline (ANOVA: $F = 729.3249$, $p = 1.3702 \times 10^{-20}$), meaning the four groups did not behave the same way at that wavelength and could be separated well enough to support screening decisions. Real sample testing is still needed to confirm repeatability and real-world performance.

Conclusions

This proof-of-concept study supports the potential of a micro-sample UV-Vis system to screen returned PCA bags for drug identity and flag possible mismatches. Simulated separation among morphine, hydromorphone, fentanyl, and saline, along with the Match / Retest / No Match framework, suggests the prototype could serve as a practical first-pass verification tool. Still, this solves only part of the problem, since future versions must also measure residual volume accurately and verify that the amount matches the documented waste.

Future Steps

Acknowledgments

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References