Deep Diamond Re-ID

Diamonds, not only a girl’s best friend

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ID: {-12, 24, 54, 1, -87, 45, 43, 67, -56, -36, 81, 42, 56, ..., 43}
Problem statement

Diamond-switching by customers or employees, and offered advice to discourage the practice. "Switches of diamonds for fake or lesser goods are done by both highly skilled thieves posing as customers and by dishonest employees," the group warned.

Trade 'Blind to Diamond-Swapping Threat'
Aug 15, 2010 10:51 AM  By Joshua Friedman

Jewelers Security Alliance: 'Beware of Switches'
Dec 9, 2008 2:50 PM  By Jeff Miller

**RAPAPORT...** Jewelers Security Alliance (JSA) reminded its retail base to watch out for diamond-switching by customers or employees, and offered advice to discourage the practice. "Switches of diamonds for fake or lesser goods are done by both highly skilled thieves posing as customers and by dishonest employees," the group warned.

Switch artists have developed an "art of disarming an unsuspecting target." They use charm and behaviors designed to impress in order to take advantage of an unguarded moment in the store. The switch is often discovered long after it happens, making it much more difficult to investigate the crime.

Several switches of diamonds for cubic zirconia (CZ) have occurred recently in retail stores, according to the JSA. These include a diamond solitaire ring that was switched in a New York store, diamond earrings and a ring in a Boston boutique and two diamonds at a mall store in Elyria, Ohio.

**RAPAPORT...** When an Israel trader at a Sherlock Holmes scene, which involved 3-5 or 6 of their bourse members on August 5.

JSA presented tips to prevent switches. Show only one item at a time, never turn your back on a customer, and wait on only one customer at a time. Be sure to reexamine the jewelry if a customer has handed it back to the staff. "It could be a CZ, moissanite or an inferior stone. You must either loupe it, or use diamond and moissanite testing equipment," the organization advised.

Additionally, stores should have selling-surface cameras, and staff should be reminded to be aware in case of distraction, as when a customer drops a diamond, or faints, or does anything else to divert attention.

JSA offers crime prevention weekly e-mails and alerts.
How does the jewelry store control the returned diamonds?

- Not!
- If they suspect that diamonds are switched:
  -> ASET (Angular Spectrum Evaluation Tool)
Our solution

Diamond re-identification

Diamond A

\[\{-12, 36, 15, 54, 98, -6, -23, 36, \ldots, 154\}\]

Diamond B

\[\{18, -76, -16, 18, 32, 21, -3, 12, \ldots, -6\}\]

Diamond C

\[\{-2, 54, 1, 12, -8, 13, -16, 89, \ldots, 47\}\]

Diamond X

\[\{18, -76, -16, 18, 32, 21, -3, 12, \ldots, -6\}\]

compare
Challenges

A

Different

B

Equal
Workflow

1: Take picture with ASET

Setup

uniform light source

Diamond

plexiglass

Camera

ASET

X-Y table 3D printer
Workflow

1: Take picture with ASET

Size: 1-3mm
Workflow

2: Generate ID (embedding)

• Start from Darknet19 classification network trained on ImageNet
Workflow

2: Calculate ID with re-identification algorithm

- Transfer learn network with training set of 100 diamonds

![Diagram showing convolutional layers, fully connected layer (1024 nodes), and classification layer with probabilities 99.9%, 0.1%, and 0% for Diamond A, Diamond B, and Diamond C, respectively.]
Workflow

2: Calculate ID with re-identification algorithm

• Drop classification layer

ID = Vector[1024]{
  -45,
  12,
  87,
  -5,
  -185,
  169,
  -47,
  -62,
  ...}
Workflow

3. Compare embeddings

Make the embedding more robust by combining multiple embeddings of 1 diamond

**multiple images**

- **Diamond A**
  - 90° rotation:
    - {18, -76, -16, 18, 32, 21, -3, 12, ... , -6}

- **Diamond B**
  - 90° rotation:
    - {18, -76, -16, 18, 32, 21, -3, 12, ... , -6}

**rotated images**

- **Diamond A**
  - 0° rotation:
    - {12, 36, 15, 54, 98, -6, -23, 36, ... , 154}

- **Diamond B**
  - 0° rotation:
    - {12, 36, 15, 54, 98, -6, -23, 36, ... , 154}
Workflow

3. Compare embeddings

- Nearest average (euclidean distance)
- SVM
- K-NN (different values for K)
Results

768 pictures of 64 never seen diamonds

100% mAP K-NN (k=5) 8 reference pictures
98.4% mAP Euclidean distance 1 reference picture
## Results

**Network configurations** (nearest average as compare technique)

<table>
<thead>
<tr>
<th>Network</th>
<th>Input res.</th>
<th>Vector dim.</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darknet V2</td>
<td>600 x 600</td>
<td>1024</td>
<td>98.4%</td>
</tr>
<tr>
<td></td>
<td>256 x 256</td>
<td>1024</td>
<td>96.9%</td>
</tr>
<tr>
<td>Darknet V3</td>
<td>600 x 600</td>
<td>1024</td>
<td>97.8%</td>
</tr>
<tr>
<td></td>
<td>600 x 600</td>
<td>128</td>
<td>97.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>256</td>
<td>95.6%</td>
</tr>
<tr>
<td>Resnet</td>
<td>600 x 600</td>
<td>256</td>
<td>97.0%</td>
</tr>
</tbody>
</table>
Summarize

In the past

Now

100% mAP K-NN (k=5) 8 reference pictures
Questions ?