Camera Identification using Statistical Process Control Techniques for Anomaly Detection

Digital Futures 2009

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Tasks of Image Forensics

Source Classification
Camera Identification
Processing History Recovery
Integrity Verification / Forgery Detection
Anomaly Investigation

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Source Classification
Camera Identification
Processing History Recovery
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Anomaly Investigation

Previous Research

Defective Pixels, noise level, image format, image headers

CFA Demosaiking [2]

JPEG Quantisation [3]
Sensor Pattern Noise [4]

2004 2005 2006 2007 2008 2009

Statistical Process Control

“Repeated measurements taken from a process will exhibit variation”
[W. Shewhart (1920s)]

If a process is stable, its variation will be predictable, but most processes are not stable

Is the cause for variance under control?
common cause variation / special cause variation

Control Charts used to graphically present degree of variance within a process
Control Charts

Aid in distinguishing between common-cause and special-cause variation

Series of process measurements taken in time order

Centreline (CL) denotes process mean

Control Limits calculated from variation within data

1. Upper Control Limit (UCL)
2. Lower Control Limit (LCL)

Identification of instances where data value falls above/below control limit boundaries

Typically two charts: one for displaying shifts in process mean, and another to display extent of variation within the process

Is the process in control? Can the process be improved?
Example of Control Charts

95% of all values lie within ±2 Standard Deviations of the mean
~5% False Positive margin

~0.27% False Positive margin when using ±3 Standard Deviations

Any value falling outside control limits are “Out of Control”

Challenge is then to find and fix reason for error

Upper Control Limit typically set as ~3 Standard Deviations above process mean

Mean of data values

Lower Control Limit set as ~3 Standard Deviations below process mean
Camera Performance

VuPoint Keychain Digital Camera
Resolution: 0.064 MegaPixels
RRP £10

Leica M8 Digital Camera
Resolution: Up to 10.3 MegaPixels
RRP £3,999
Scene 1 (Skittles)

Assortment of Skittles and Smarties used to provide vast colour changes

10 angles for potential cross-comparison of light interpretation

10 shots taken per angle to derive behavioural patterns of each device
Test Cameras

4x
Apple iPhone 3G

Sony Ericsson
W810i

Samsung
NV3

All camera settings set to match the most basic camera (iPhone) (i.e. 2 MegaPixel Resolution, No Flash, Zoom Out)
## iPhone Data

### Scene 1, Angle 5

Mean of all shots*

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*Mean calculated in spatial domain for all colour planes*
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# Sony Ericsson W810i Data

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## Samsung NV3 Data

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**Mean of all shots**

*Mean calculated in spatial domain for all colour planes*

To plot *Moving Range* charts:
Calculate range between neighbouring values
X-Moving Range Control Charts
iPhone A: Angle 5

**X Chart Calculations**

\[
UCL_x = \bar{X} + 3\sigma_x = 105.461 + (3)(1.011) = 108.497
\]

\[
\bar{X} = \frac{\sum X_i}{10} = \frac{1054.613}{10} = 105.461.
\]

\[
LCL_x = \bar{X} - 3\sigma_x = 105.461 - (3)(1.011) = 102.426.
\]

**R_m Chart Calculations**

\[
UCLR_m = D_4 R_m = (3.27)(1.141) = 3.729
\]

\[
\bar{R}_m = \frac{\sum R_{mi}}{9} = \frac{10.27}{9} = 1.141.
\]

\[
LCLR_m = D_3 \bar{R}_m = (0.0)(0.294) = 0.0
\]
X-Moving Range Control Charts

iPhone B: Angle 5
X-Moving Range Control Charts

iPhone C: Angle 5
X-Moving Range Control Charts
iPhone D: Angle 5
X-Moving Range Control Charts

Sony Ericsson W810i: Angle 5
X-Moving Range Control Charts
Samsung NV3: Angle 5
Depth of Variation
Per-camera

![Graph showing depth of variance per camera model](image)
Summary

• Control Charts can help derive quality of a camera’s image acquisition process

• Anomalies in the process are highlighted through control charts

• Honing in on the cause of these anomalies, ultimately solves Camera Identification problem