Digital Camera Identification

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The Problem

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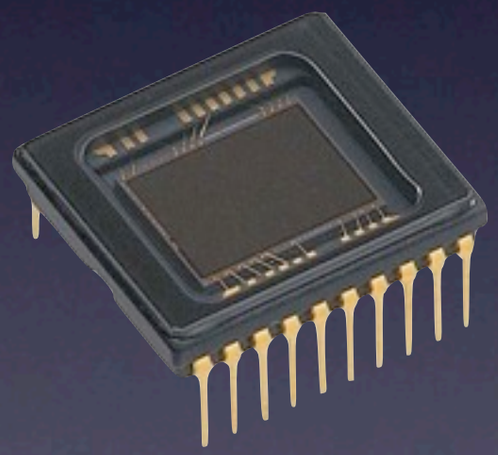
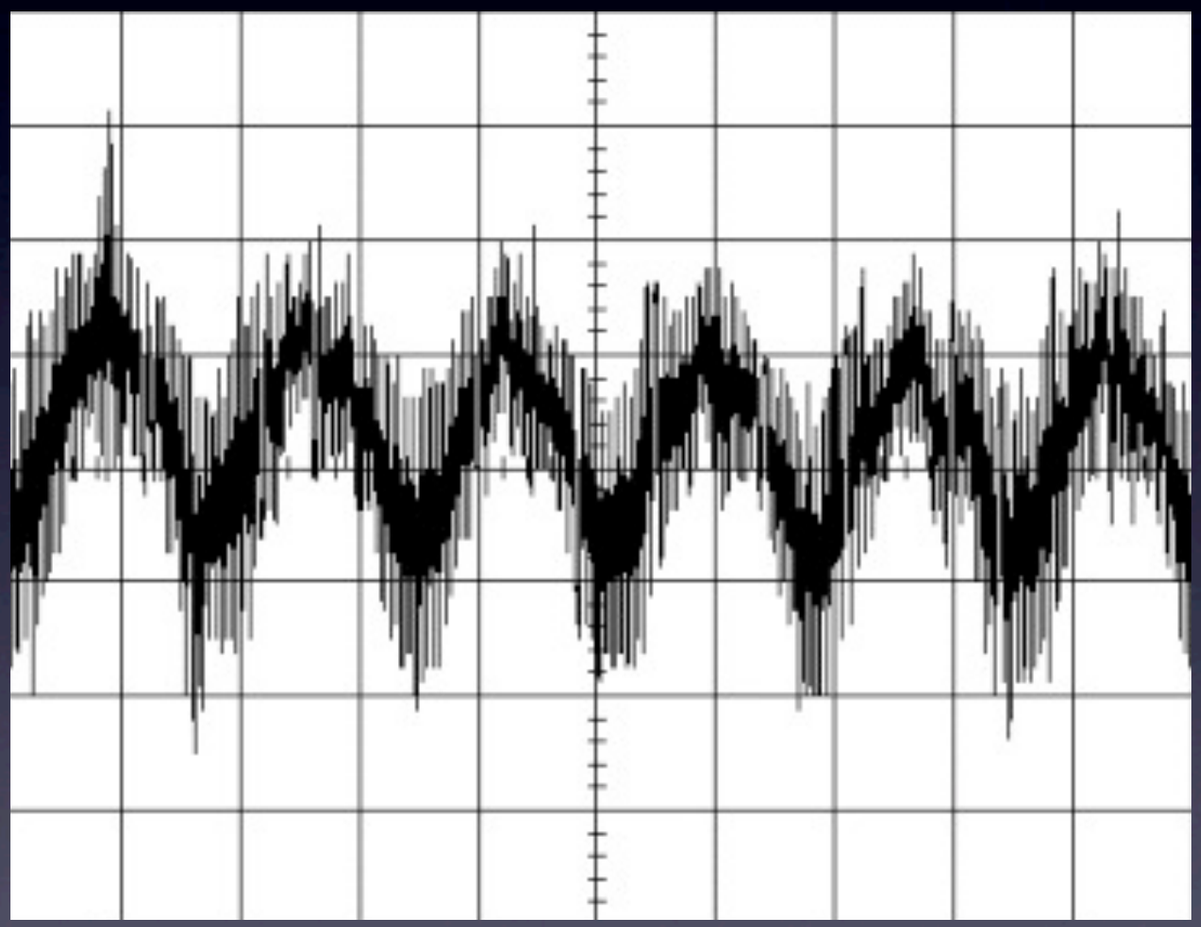
The Digital Image Pathway

Light



Magic

Noise



- Shot noise
- Pattern noise
  - Fixed pattern noise
  - Photo-response non-uniformity noise (PRNU)

Modelling the Sensor Output

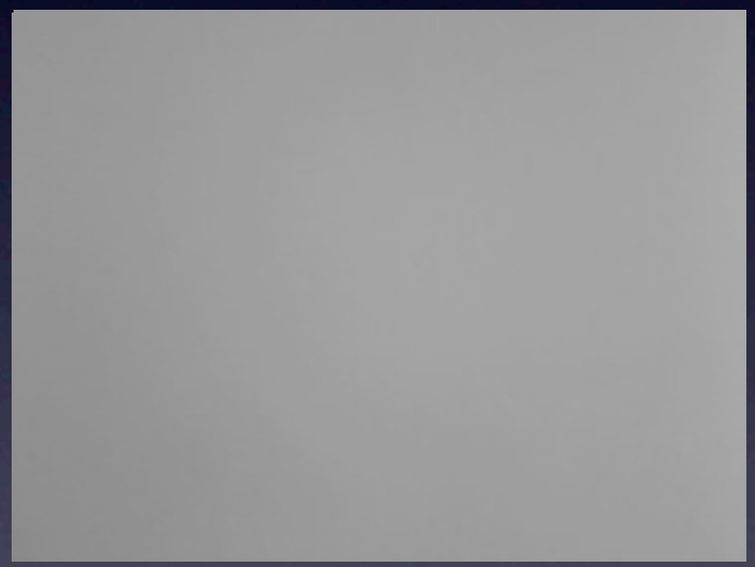
$$y_{ij} = f_{ij}(x_{ij} + \eta_{ij}) + c_{ij} + \varepsilon_{ij}$$

The Algorithm

1. Calculate the camera reference patterns
2. Look for correlation between the image and the different patterns

Calculating the Reference Pattern

Calculating the Reference Pattern



Looking for Correlation

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Looking for Correlation

Looking for Correlation

Looking for Correlation

Original Image

Filtered Image

Looking for correlation

Original Image

Filtered Image

Looking for Correlation

Original Image

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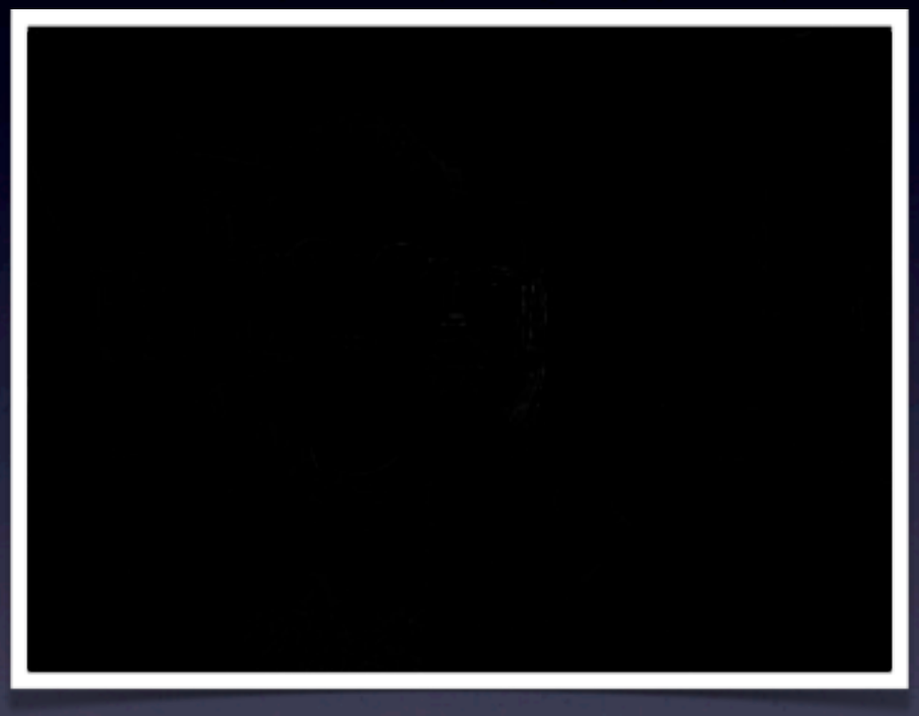
Filtered Image

Looking for Correlation



Noise Residual

Looking for Correlation

$$corr(\mathbf{n}, \mathbf{r}) = \frac{(\mathbf{n} - \overline{\mathbf{n}}) \cdot (\mathbf{r} - \overline{\mathbf{r}})}{\|\mathbf{n} - \overline{\mathbf{n}}\| \|\mathbf{r} - \overline{\mathbf{r}}\|}$$

Experiment

Experiment

100x

Experiment

Experiment

Results

Webcam Images

Other Images

Paper results

- Setting FAR to 10^{-3} gives FRR of 4.68×10^{-3} in worst case and down to 1.14×10^{-11}
- Gamma correction of images barely affects reliability
- JPEG also irrelevant unless high compression
- Stable over time

Algorithm Mark II

- More detailed mathematical model of how light is captured by sensor

$$\mathbf{I} = g^{\gamma} \cdot [(\mathbf{1} + \mathbf{K})\mathbf{Y} + \mathbf{\Lambda} + \mathbf{\Theta_s} + \mathbf{\Theta_r}]^{\gamma} + \mathbf{\Theta_q}$$

Algorithm Mark II

- Determine PRNU using a maximum likelihood estimator
- Detection is binary hypothesis testing
- Correlation Predictor

Large scale test

- Apply algorithm to 1,000,000+ images
- Extensive test of reliability
- False rejection rate < 0.024 when threshold such that false acceptance < 2.4

Questions