TIADPE

Location Based Services and mean/median denoising position data

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Outline

Location based services

Moving average filtering position data

Moving median filtering position data

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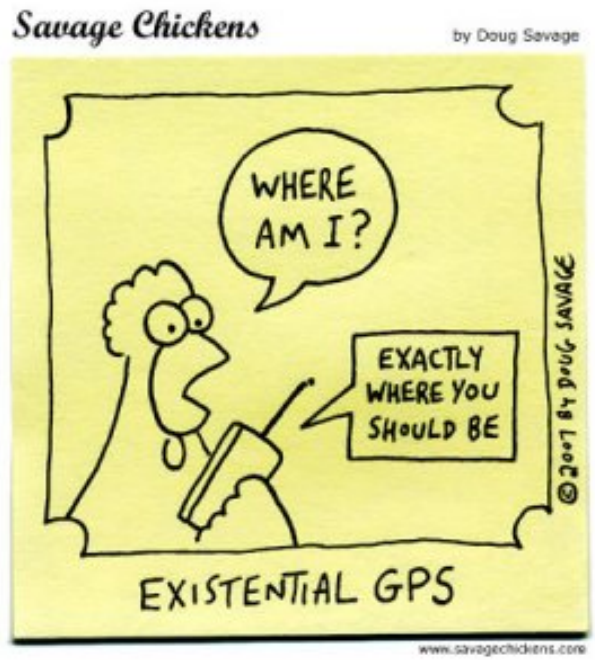
Location based services

Location based services (LBS)

- (IT) Services that use location data to control service features



LBS application examples

Navigation
- Route planning and emergency assistance

Tracking and locating
- Persons, pets and valuable assets

Social networking
- Friend-finder and instant messaging

Billing and alerting
- Road/parking billing and promotion alerting

Network operatorations
- Location sensitive billing and wireless network optimization

LBS application examples (cont'd)

Figure : LBSs have increased dramatically with modern smart phones

LBS design challenges

Positioning technologies

- Different levels of accuracy required for various services

Privacy

- Users care about their privacy

Interoperability

- How to scale from niche to mass market service

Emergency services

- Reliability and accuracy if delivering emergency call locations

LBS concepts

Position

- Coordinates, e.g. WGS84 (most GPSs and Google maps)
- (56.158404, 10.199436800000058)

Location

- Descriptive location in the real world
- "Vesterbro Torv, DK-8000 Aarhus"

Location service

- Generation and delivery of location data
- "Where am I?"

Location based service

- Adds value to the location data
- "Show me the direction to Vesterbro Torv"

Examples of data sources for positioning

Data source examples

- GPS and A-GPS
- RSSI of WiFi, Bluetooth and Bluetooth LE
- GSM cell information

Common challenge

- Often noisy and needs filtering

Methods for filtering positioning data include

- Moving average or median, exponential smoothing
- Low pass, Savitzky–Golay, Kalman

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Moving average filter

- Smooth short-term fluctuations and highlight long-term trends
- Signal of averages of neighbouring samples
- Size of neighbourhood is determined by window size, WS
- A one dimensional moving average filter is a difference eq.

$$y(n) = \frac{1}{\mathrm{WS}}\Big(x(n-0) + x(n-1) + \ldots + x(n-(\mathrm{WS}-1))\Big)$$

- Weights may be added according to application
- In d dimensions we average across a kernel, k, of size, n

WiFi received signal strength indicator (RSSI) data

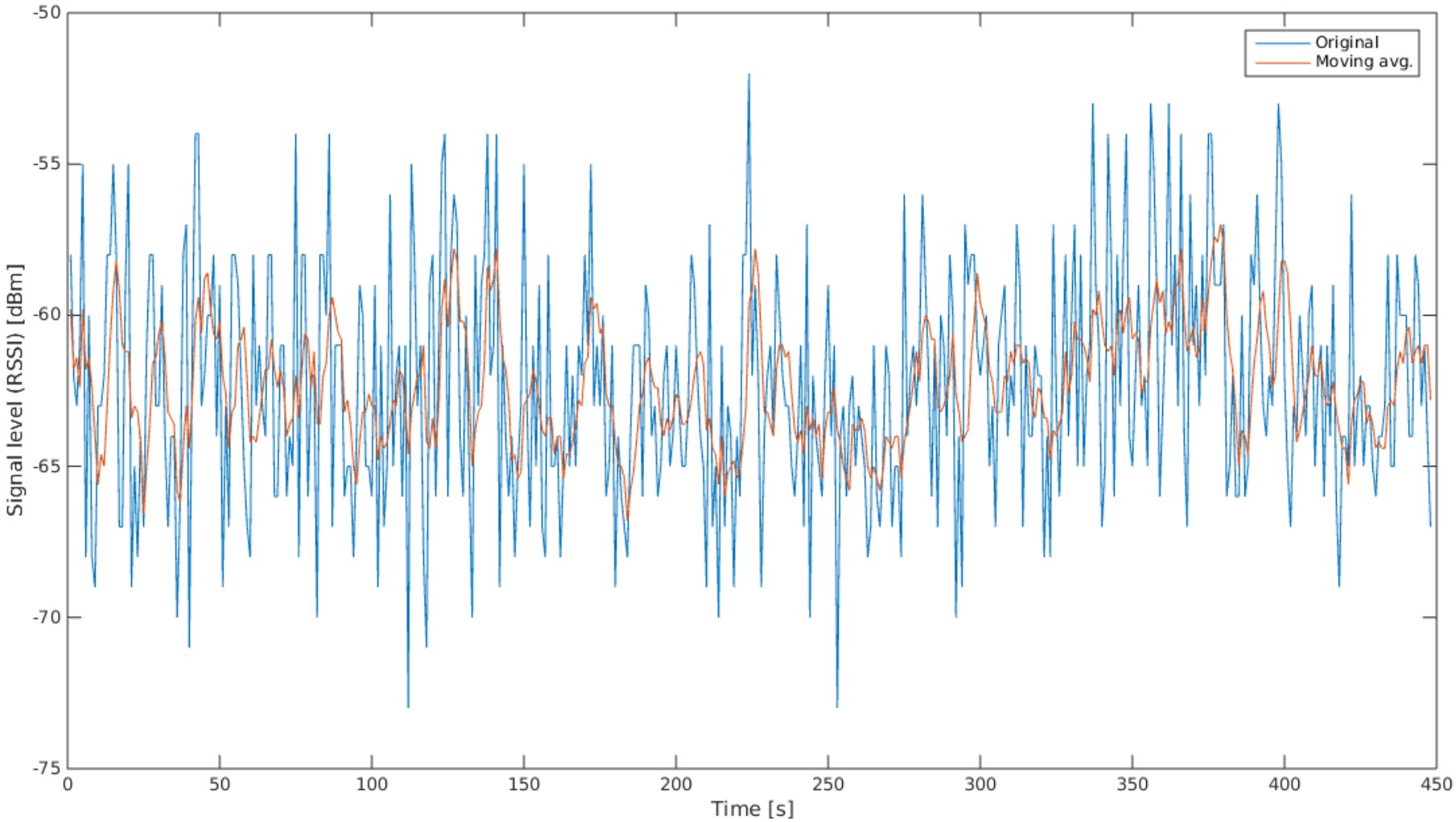

Figure : Moving average filtered WiFi RSSI data (window size=5)

RSSI unit: Decibel-milliwatt [dBm]

- Power ratio in dB: Measured power referenced to 1 mW
- Absolute unit (for absolute power) as referenced to Watt
- A power level of 0 dBm corresponds to a power of 1 mW
- A 3 dB increase/decrease $\approx$ doubling/halving the power
- Express power P in mW as x in dBm and vice versa

$$x = 10 \cdot \log_{10} \frac{P}{1\text{mW}} \quad \Leftrightarrow \quad P = 1\text{mW} \cdot 10^{x/10}$$

Some common RSSI levels

802.11/WiFi received signal power

- Max: -10 dBm $\approx 100 \cdot 10^{-6}$ W
- Min: -100 dBm $\approx 100 \cdot 10^{-15}$ W

GPS satellite received signal power

- Typical: -127.5 dBm $\approx 178 \cdot 10^{-18}$ W

Path estimation with synthetical GPS data

- Location example: GPS data corrupted by Gaussian noise
- Mean of n neighbouring samples (here $n = 3$)

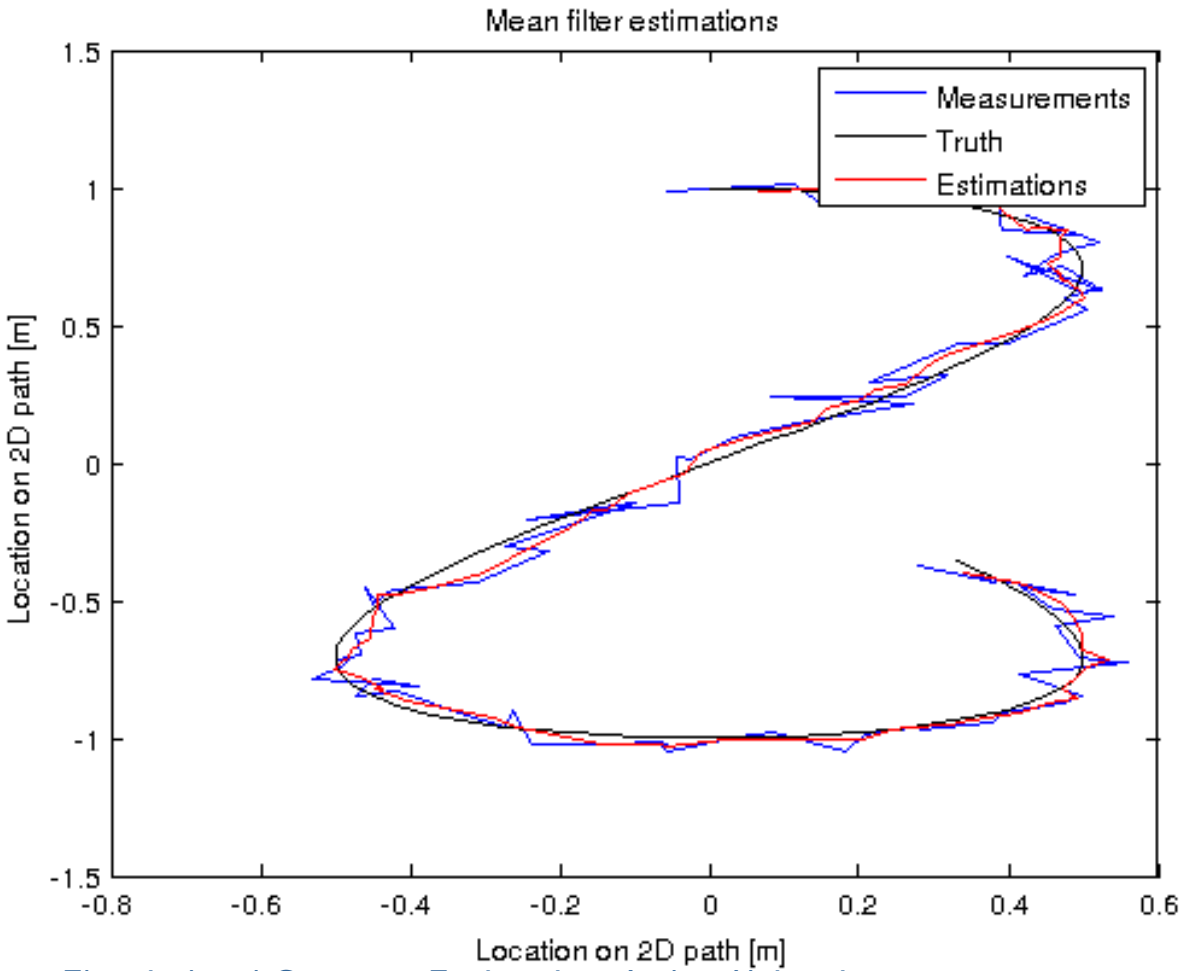

Image restoration

- Noisy image mean filtered w/ $n \times n$ kernel (here $n = 3$)

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WiFi received signal strength indicator (RSSI) data

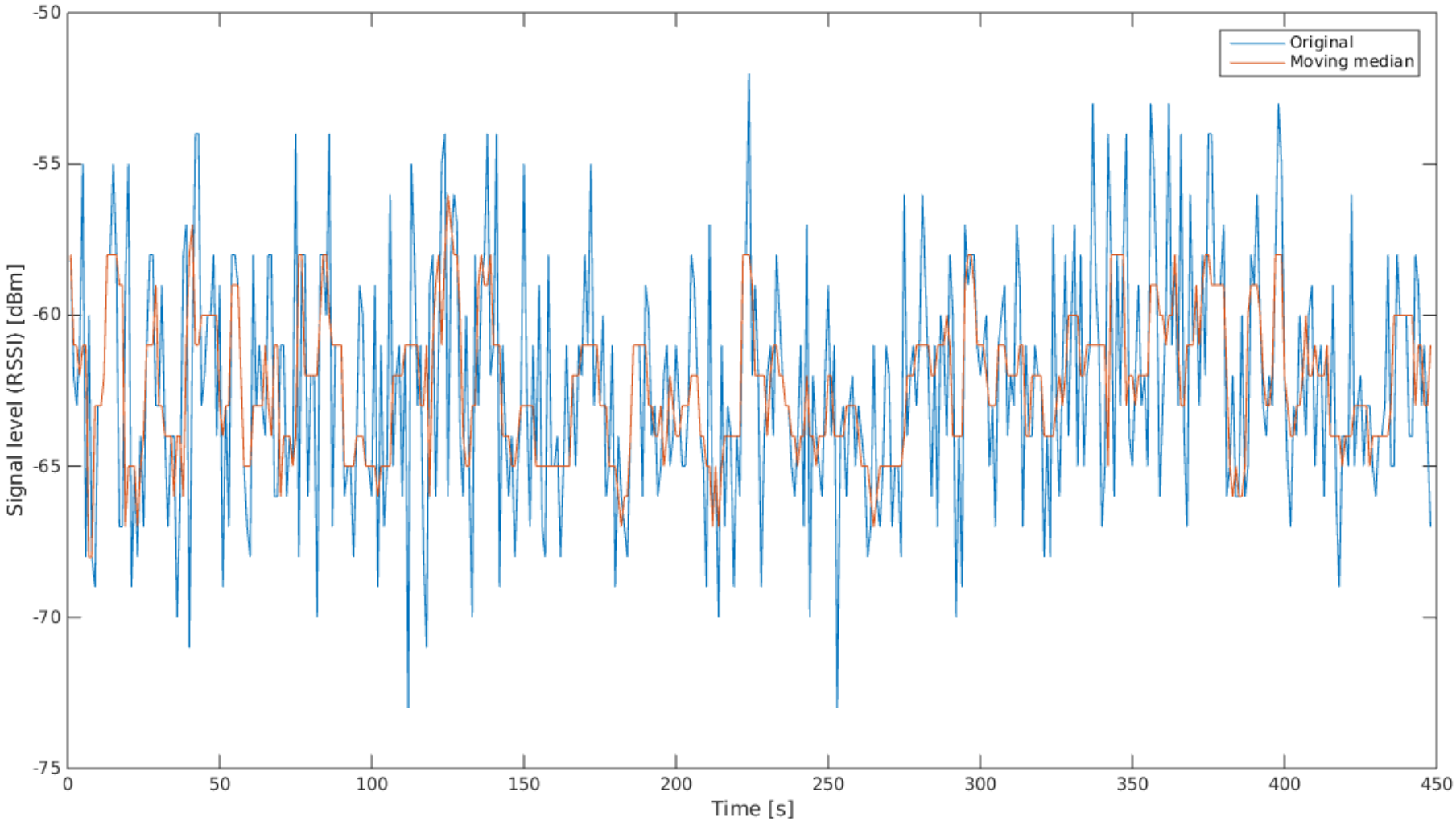


Figure : Moving median filtered WiFi RSSI data (window size=5)

Path estimation with synthetical GPS data

- Location example: GPS data corrupted by Gaussian noise
- Median of n neighbouring samples (here $n = 3$)

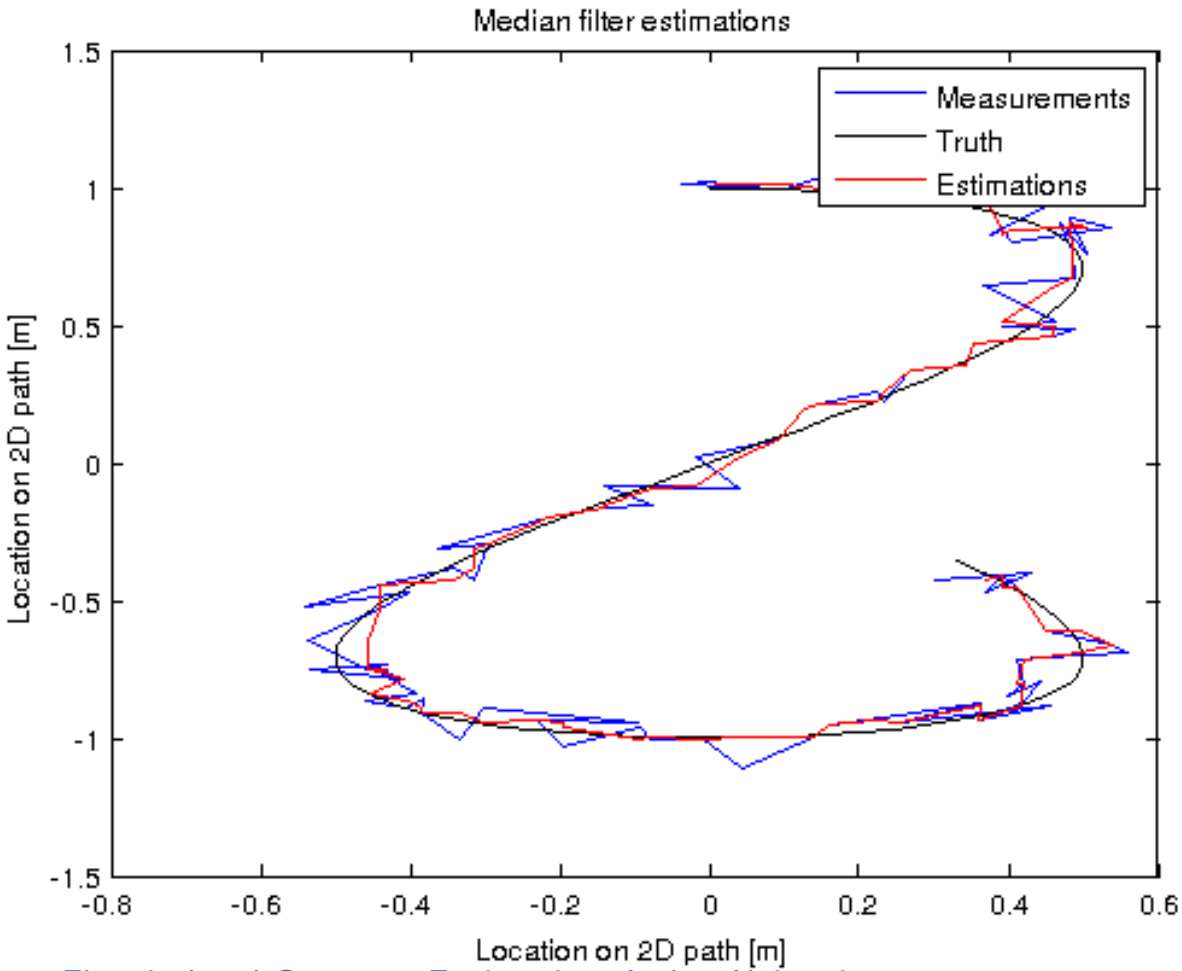
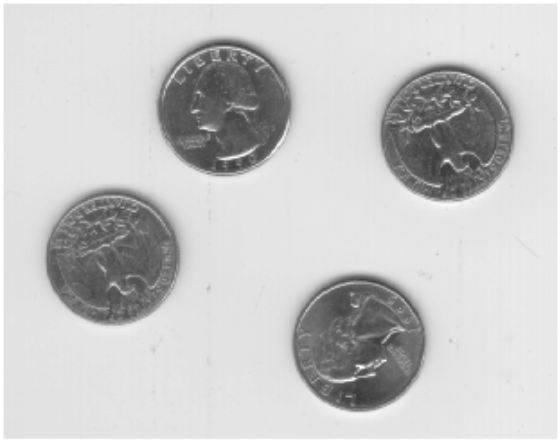


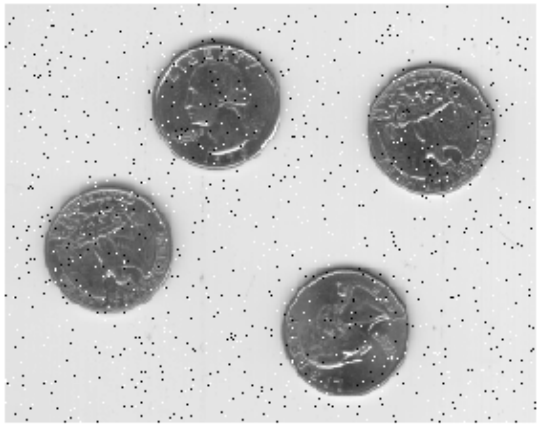
Image restoration

- Noisy image median filtered w/ $n \times n$ kernel (here $n = 3$)

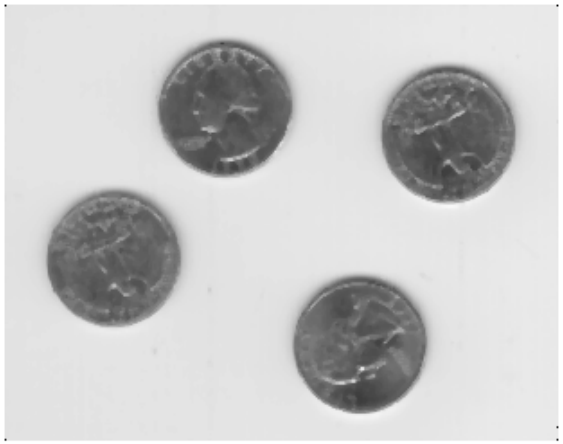
Truth



Measurement



Estimation



Difference between truth and estimation