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A Field Test of Parametric WLAN-Fingerprint-Positioning Methods

(submission 40)

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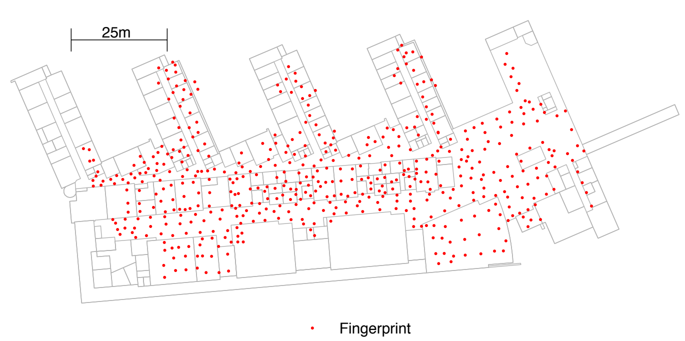
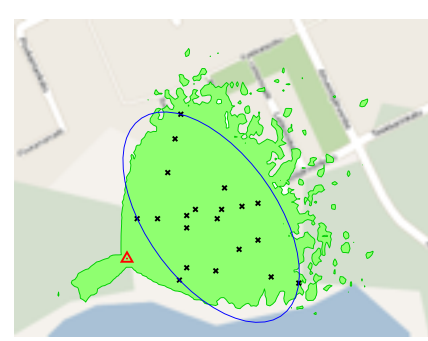
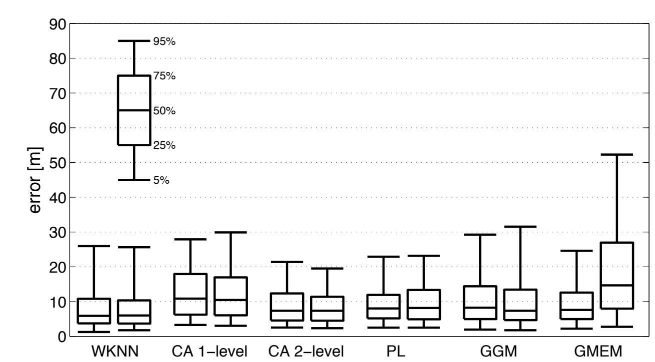


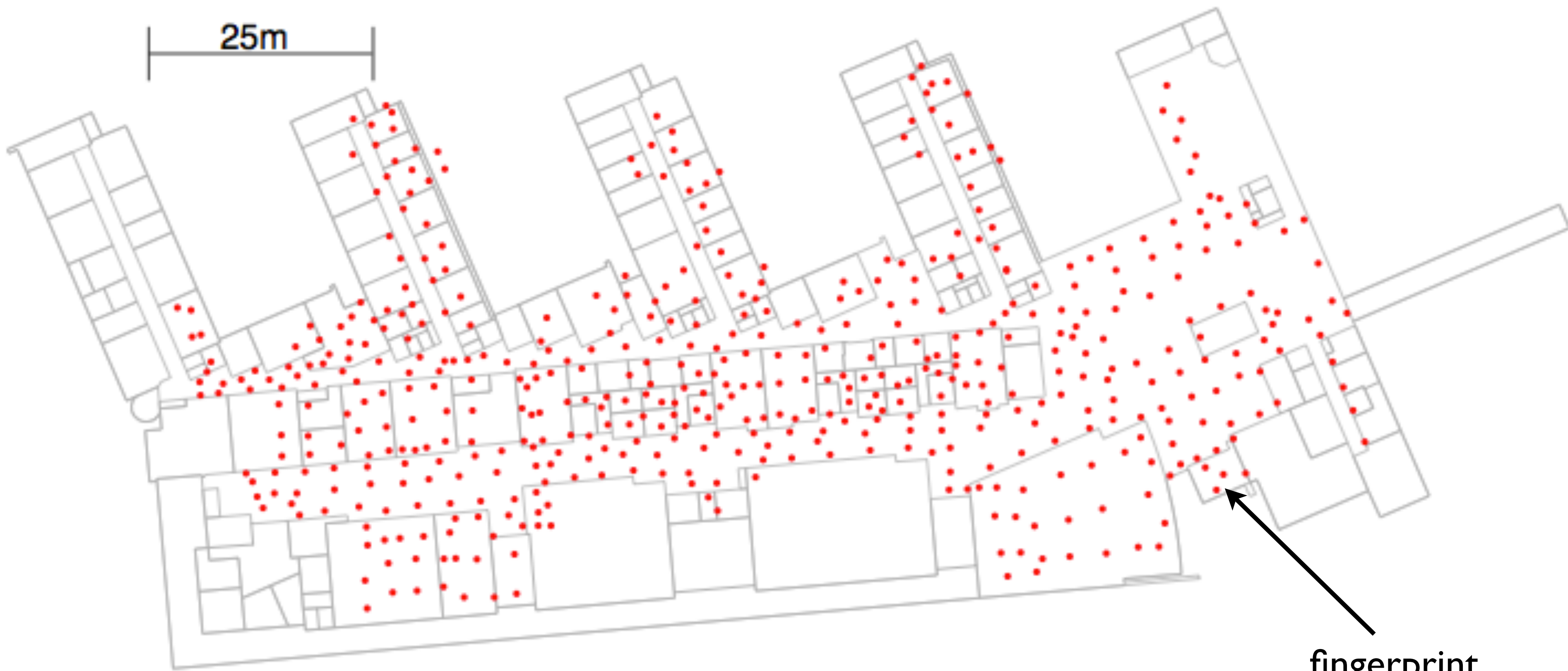
1. Nonparametric methods


2. Parametric methods



3. Field test results

Nonparametric fingerprint methods require large radio maps that grow as more training data is collected

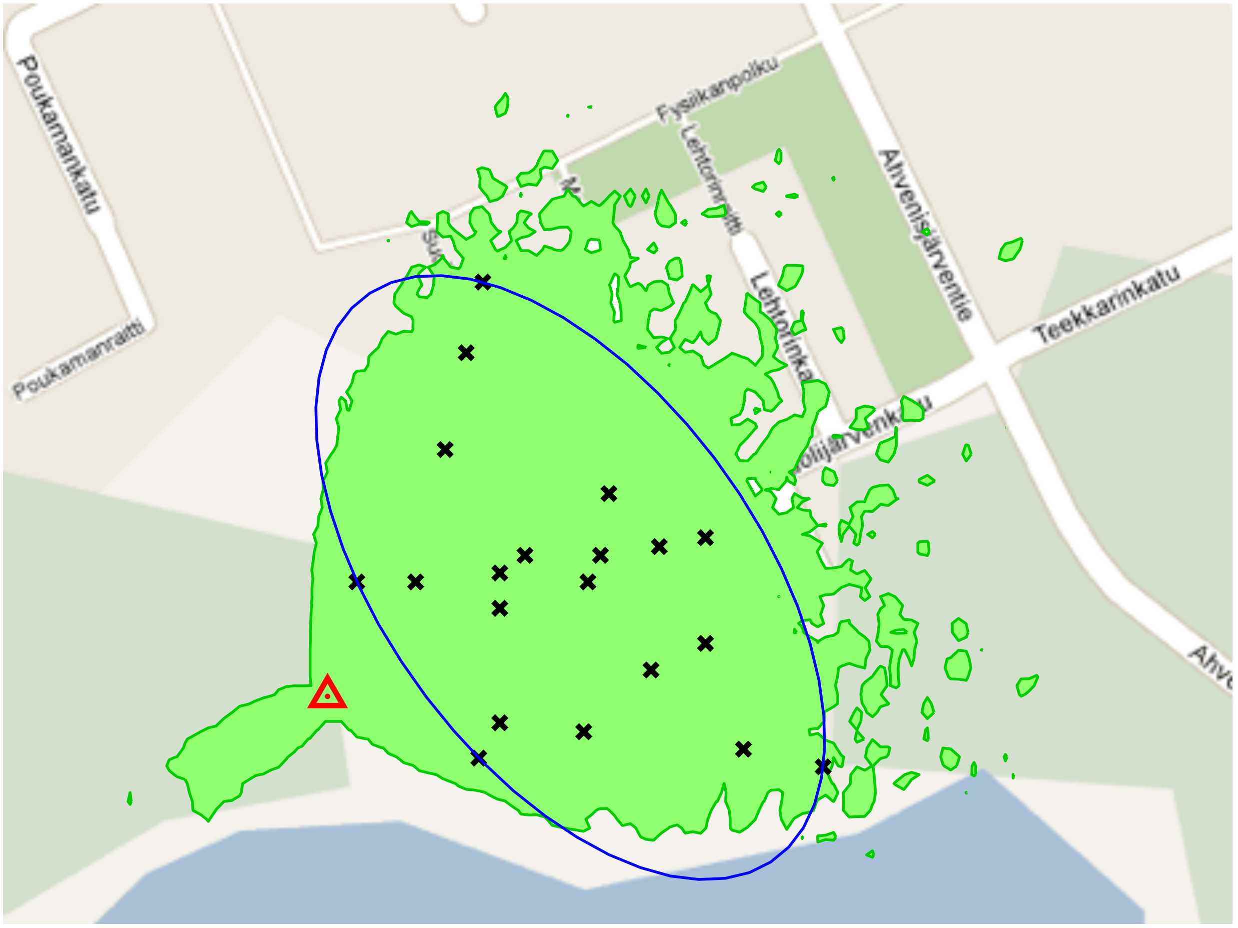


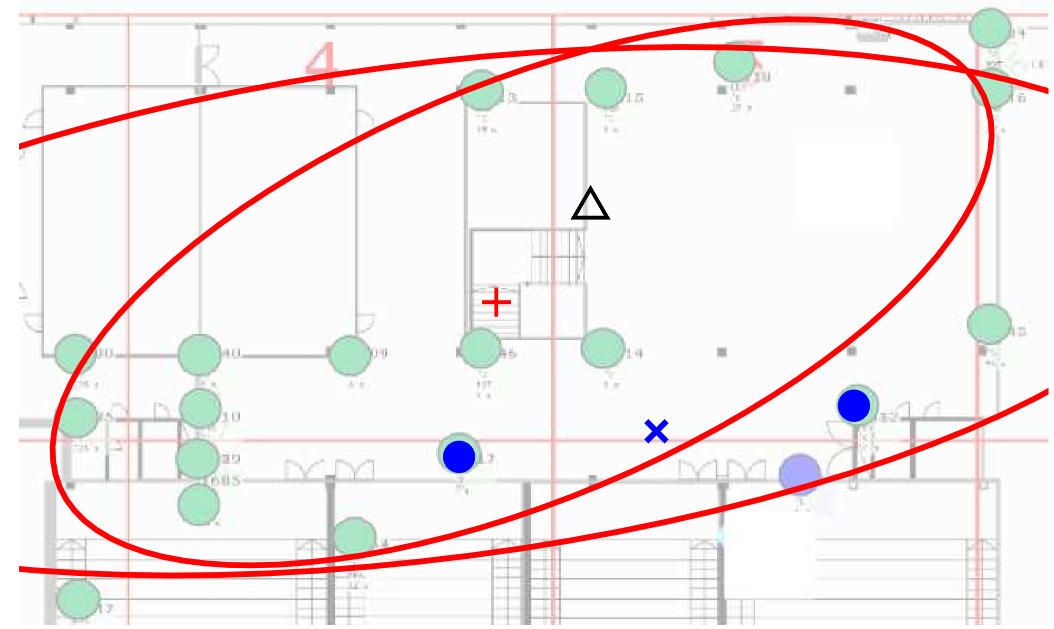
Radio map size depends on no. of fingerprints

Its transmission to a user device can be too slow for real time positioning

Also, the radio map itself requires large storage

Coverage area estimated by an elliptical probability distribution requires 5 parameters





Koski et al. 2010

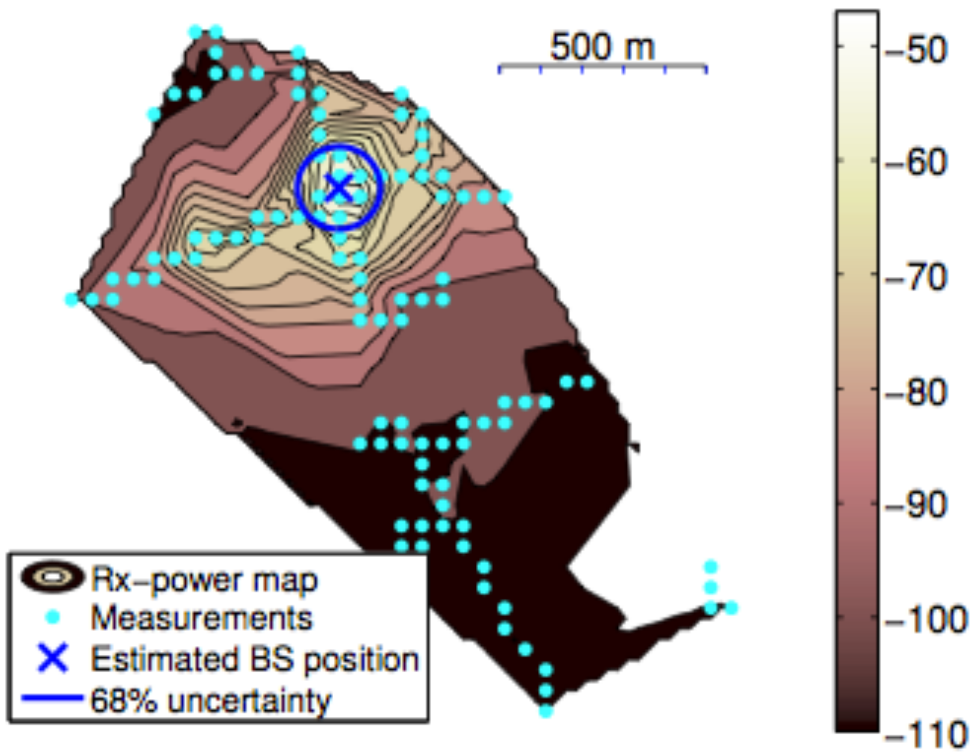
Wirola et al. 2010

Raitoharju et al. 2013

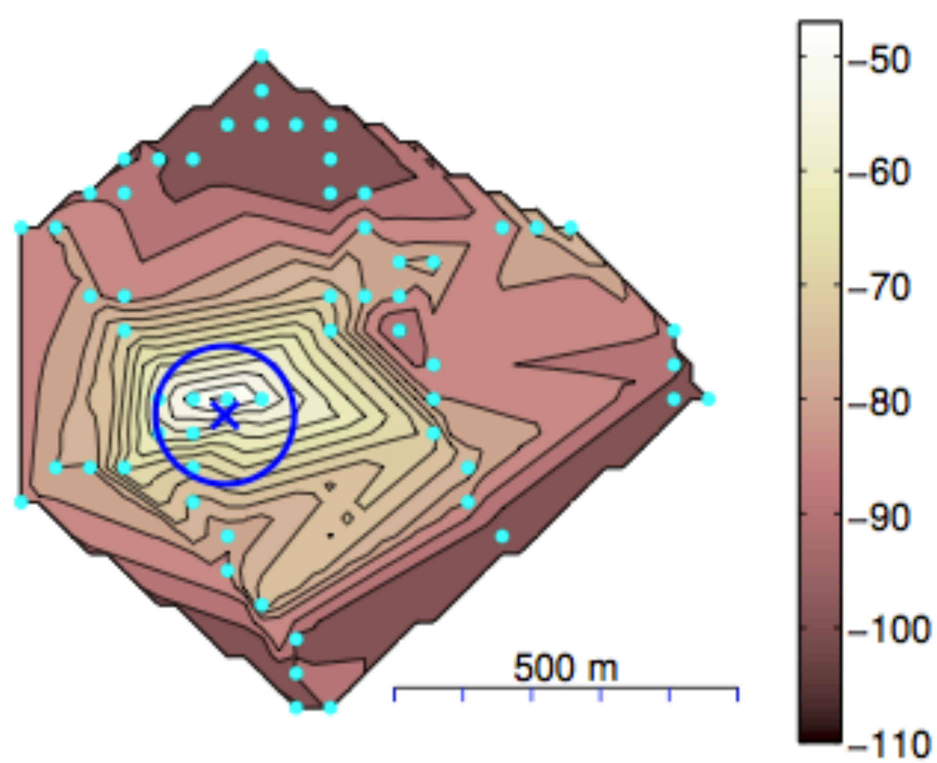
Method models fingerprints of AP as a Gaussian distribution

It uses Bayes' rule $p(x|y) \propto p(x)p(y|x)$ to compute position

Distance from access point to user device can be estimated using a path loss model



models of signal power loss or received signal strength



$$P_{\mathrm{RSS}}(d) = A - 10n\log_{10}(d) + w$$

Nurminen et al. 2012 (IPIN)

Nurminen et al. 2012 (UPINLBS)

Image adapted from Nurminen et al., "Statistical path loss parameter estimation and positioning using RSS measurements" in *Ubiquitous Positioning Indoor Navigation and Location Based Service (UPINLBS2012)*, pages 1-8, October 2012

Received signal strength distribution can be approximated by a Gaussian mixture

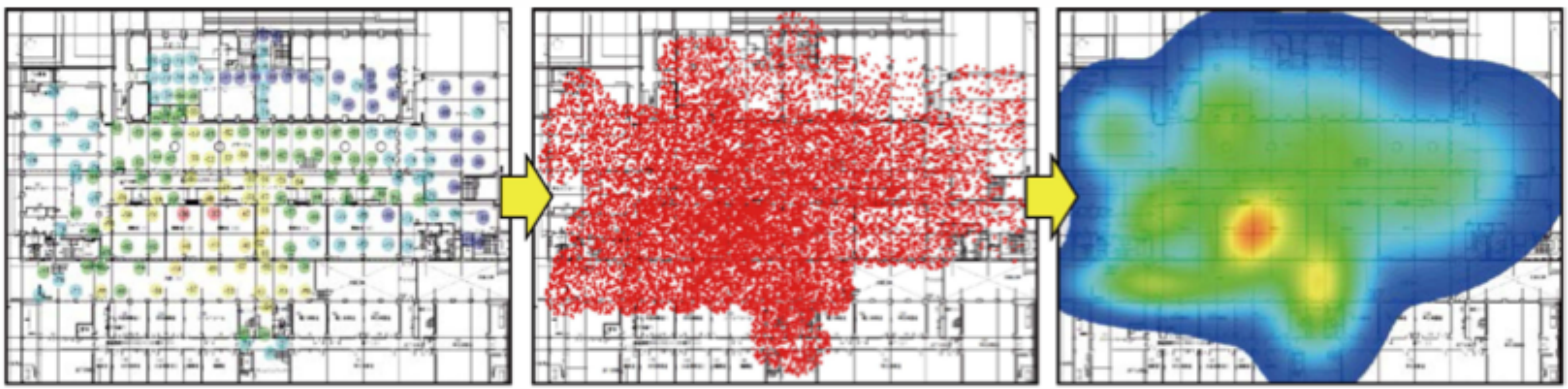


Image adapted from K. Kaji and N. Kawaguchi, "Design and implementation of WiFi indoor localization based on Gaussian mixture model and particle filter," in *2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN)*, November 2012

A Gaussian mixture is defined as

$$p(\mathbf{x}) = \sum_{n=1}^{N} \omega_n \mathcal{N}(\mathbf{x}; \mu_n, \mathbf{\Sigma}_n)$$

where weights $\omega_n > 0$ and $\sum_{n=1}^{N} \omega_n = 1$

Measurement likelihood can be approximated by a generalized Gaussian mixture

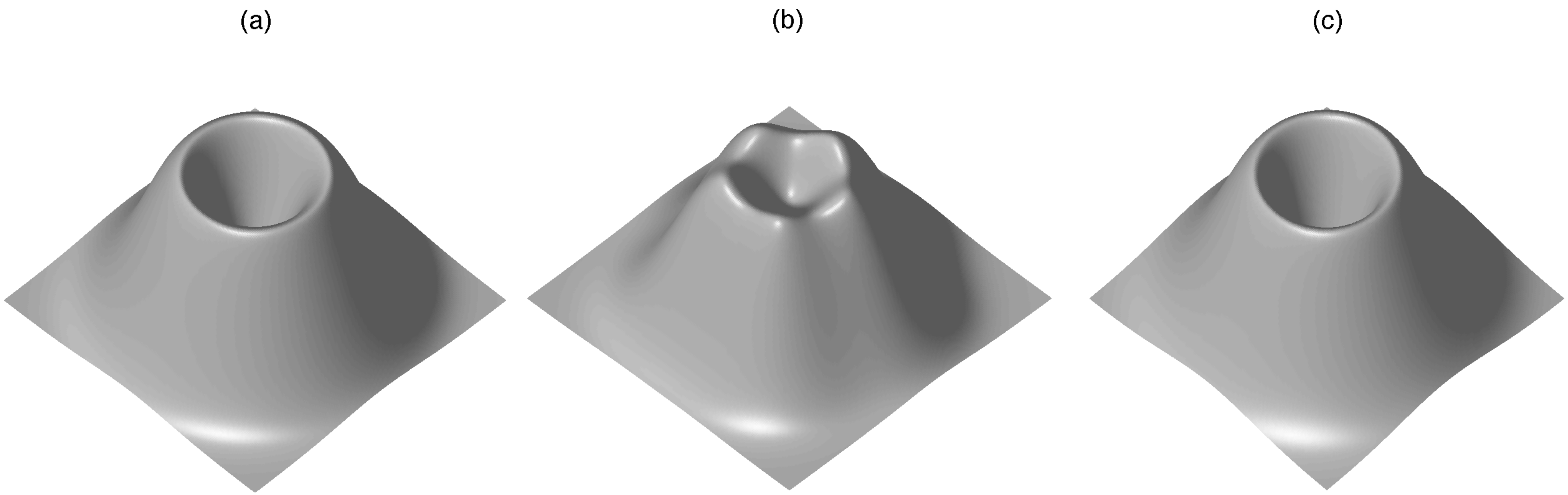


Image adapted from Müller et al., "UWB positioning with generalized Gaussian mixture filters," in *IEEE Transactions on Mobile Computing*, 2014 (in press)

Müller et al. 2012

Müller et al. 2014

$$p(y_{k,j}|\mathbf{x}_k) \approx \mathcal{N}(\mathbf{m}_1(y_{k,j}); \mu_{k,j}^{(1)}, \mathbf{\Sigma}_{k,j}^{(1)}) \cdot \left(1 - \bar{c} \cdot \mathcal{N}(\mathbf{m}_2(y_{k,j});\ \mu_{k,j}^{(2)}, \mathbf{\Sigma}_{k,j}^{(2)})\right)$$

one component can have negative weight

Field test was done at Tampere University of Technology, Finland

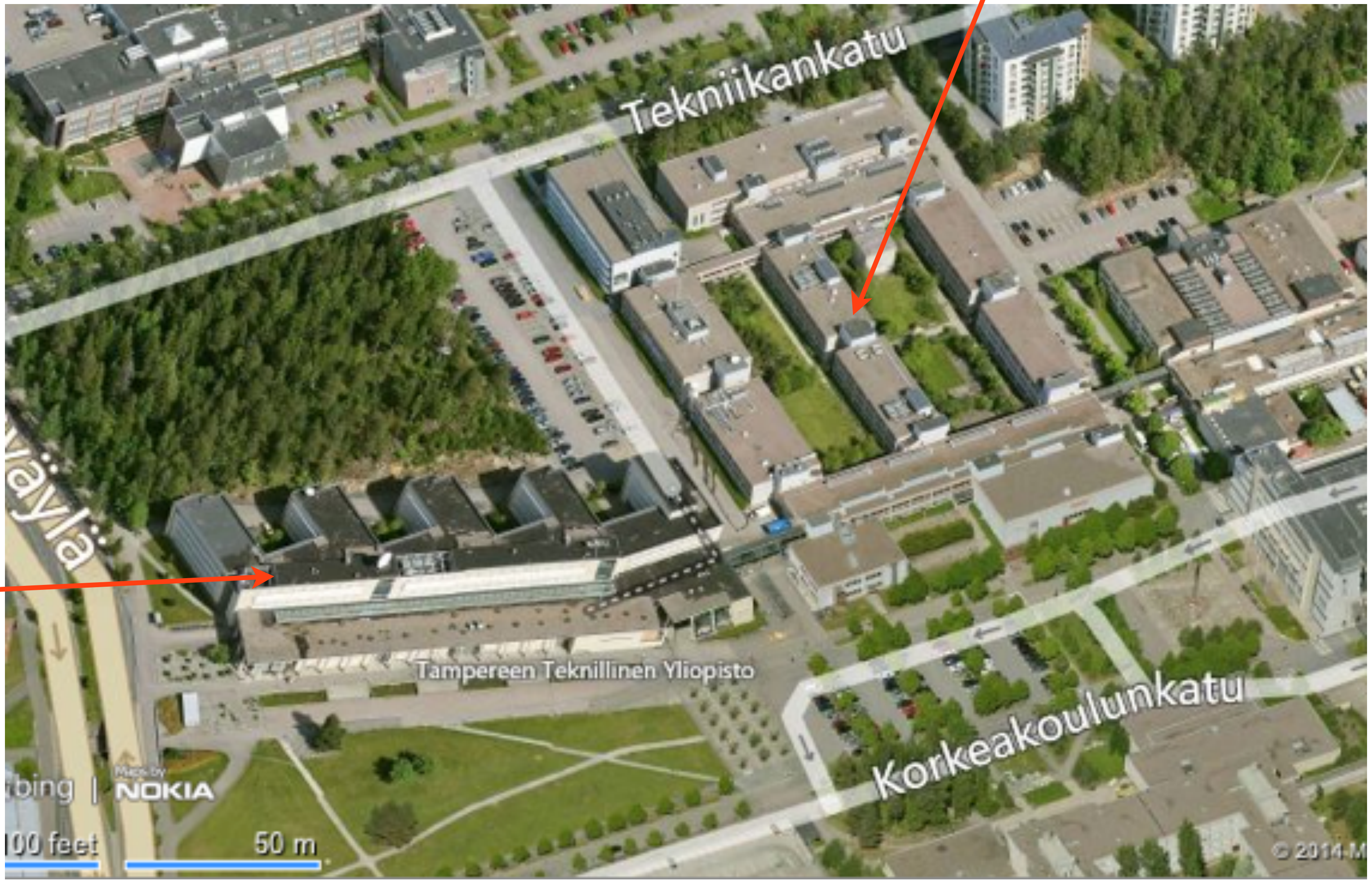
2 buildings, each with 3 floors, 48 000 m^2

506 access points

4 737 fingerprints

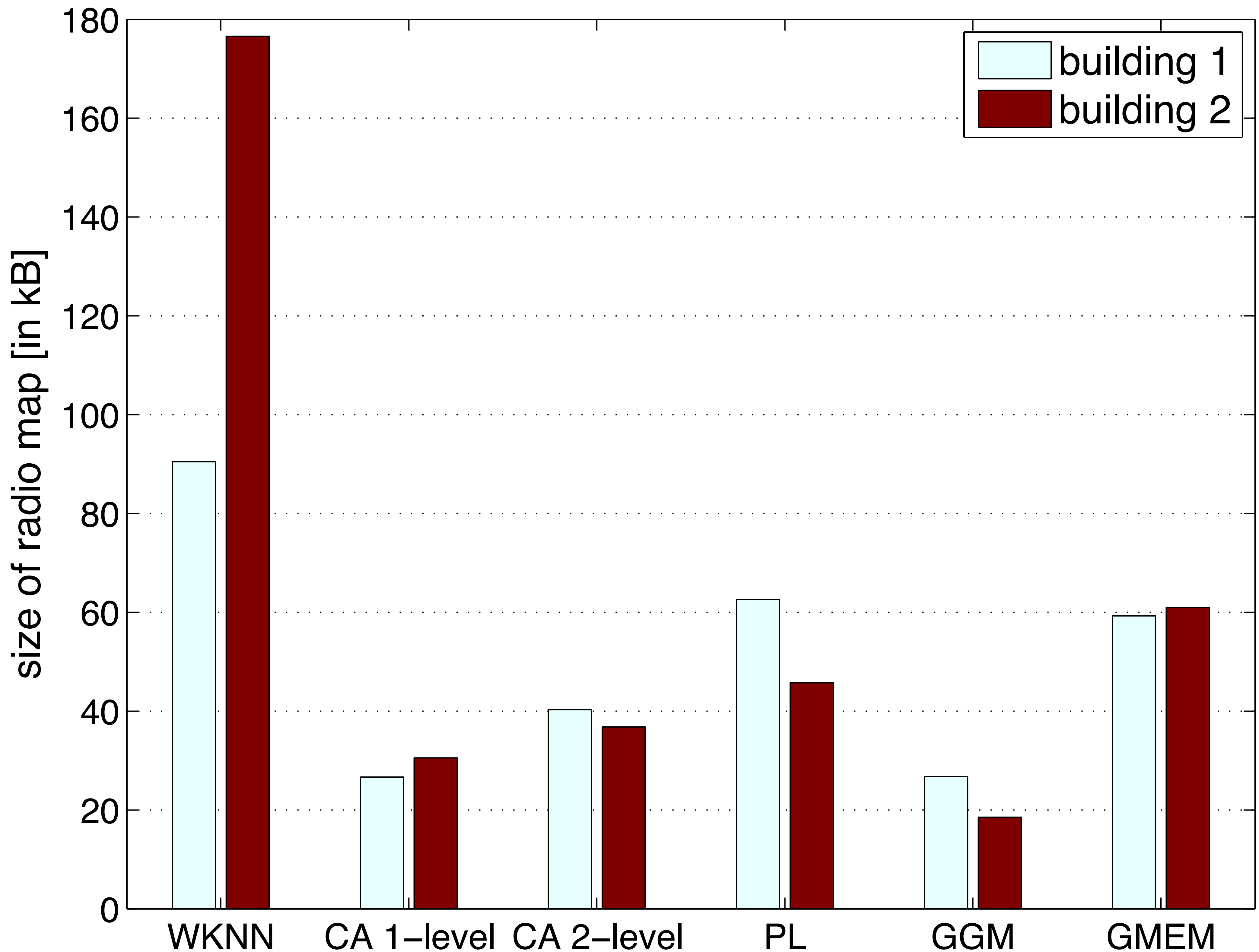
4 tracks with 308 position estimates

building 1

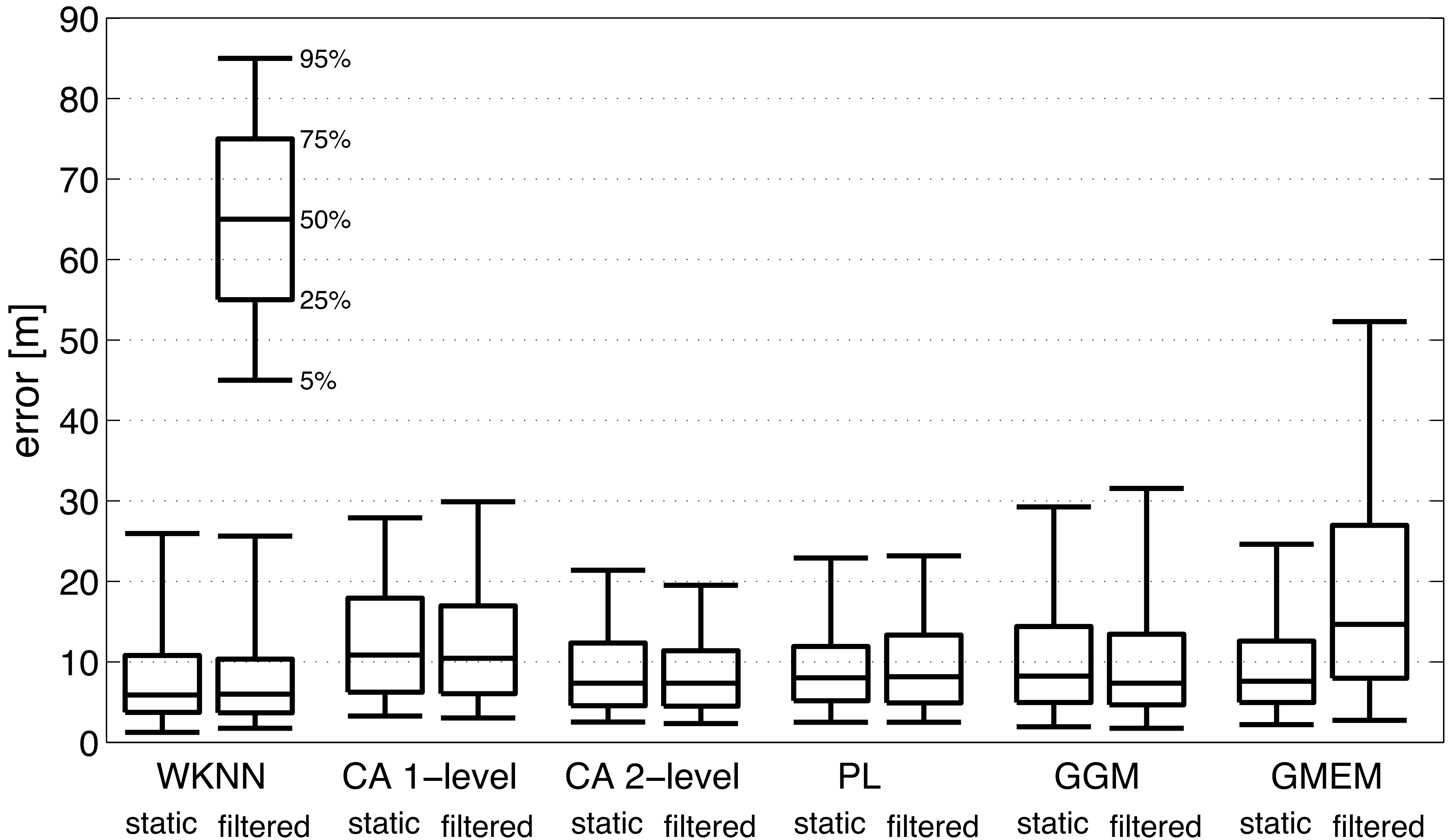


building 2

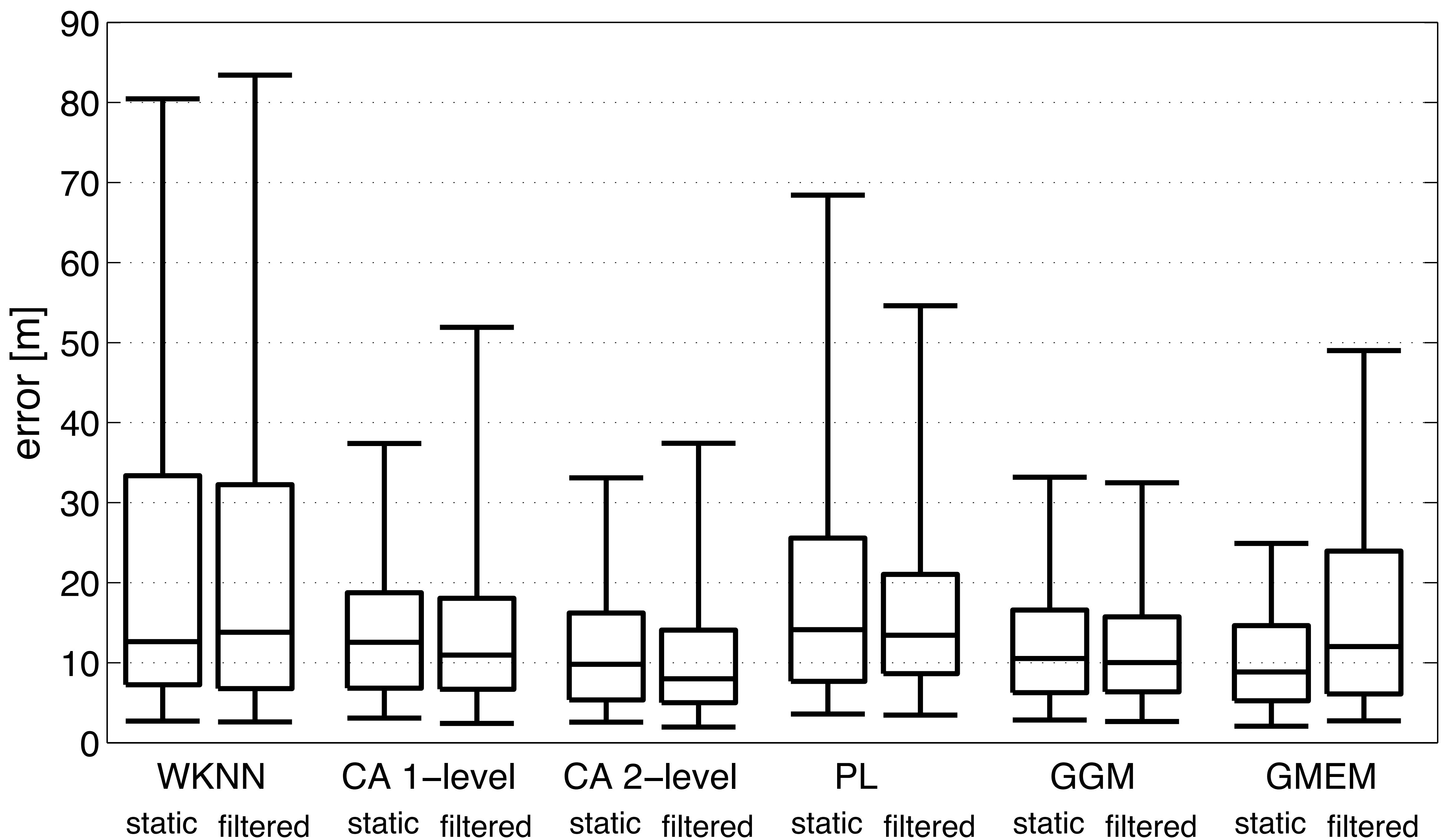
Parametric methods reduced radio map sizes between 30% and 90% in our tests



Nonparametric method is slightly more accurate than parametric methods when using all available data (506 access-points)



Parametric methods are more accurate than nonparametric method for low access-point density (51 access points)



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Parametric methods reduce radio map size and provide similar or better positioning accuracy than nonparametric method

Radio map size is reduced by 30% to 90% in our tests

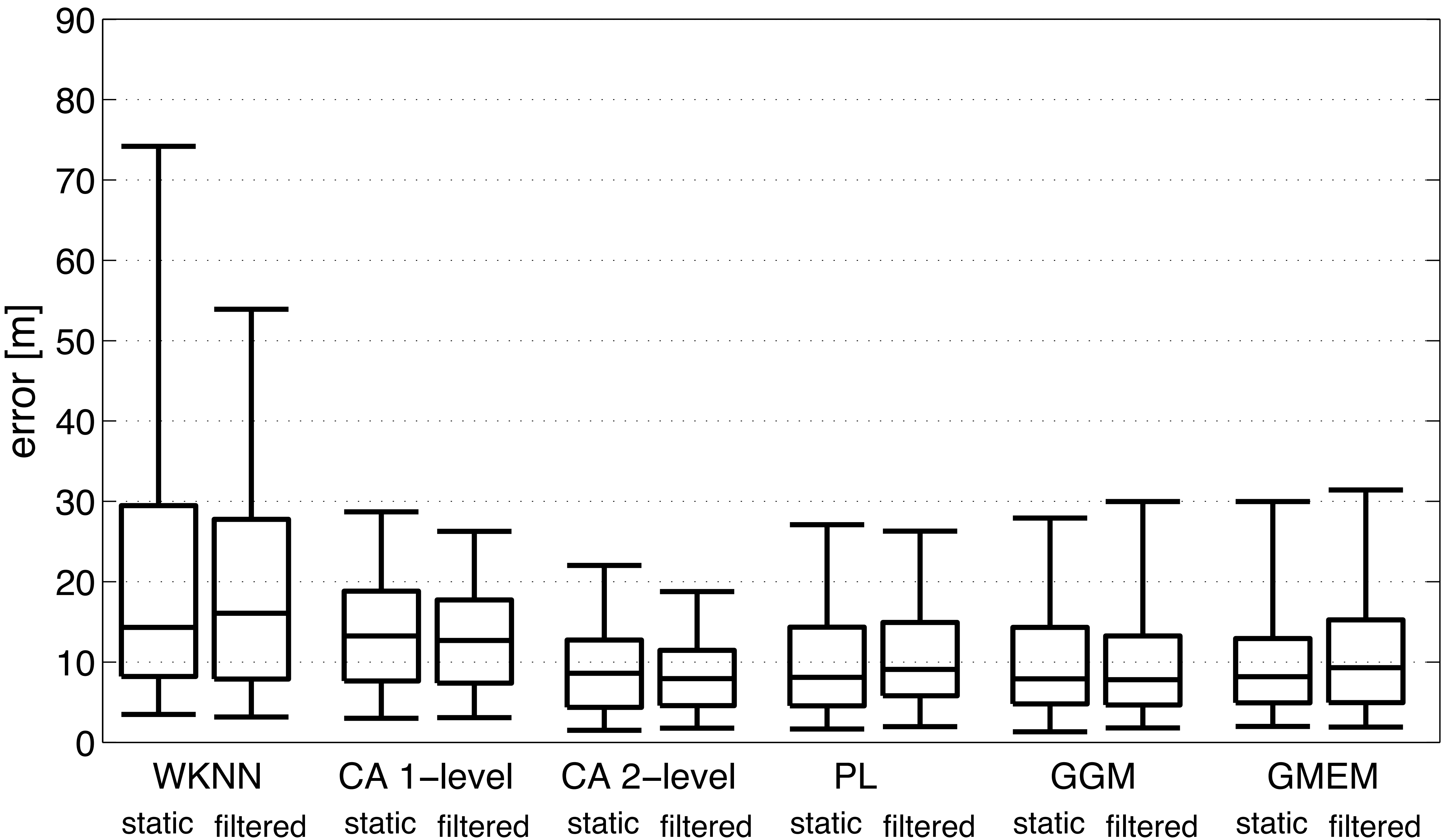
Nonparametric and parametric methods show similar accuracies for high access-point density

Accuracies of parametric methods worsen only slightly for low access-point densities

More test results can be found in our paper

Thank you!
Questions?

Parametric methods are more accurate than nonparametric method when only 5 strongest access points are used for positioning



Positioning accuracy suffers for all methods when radio map is outdated