Accuracy Evaluation of Person Position Estimation Using Compressed CSI Under Temporary Shielding

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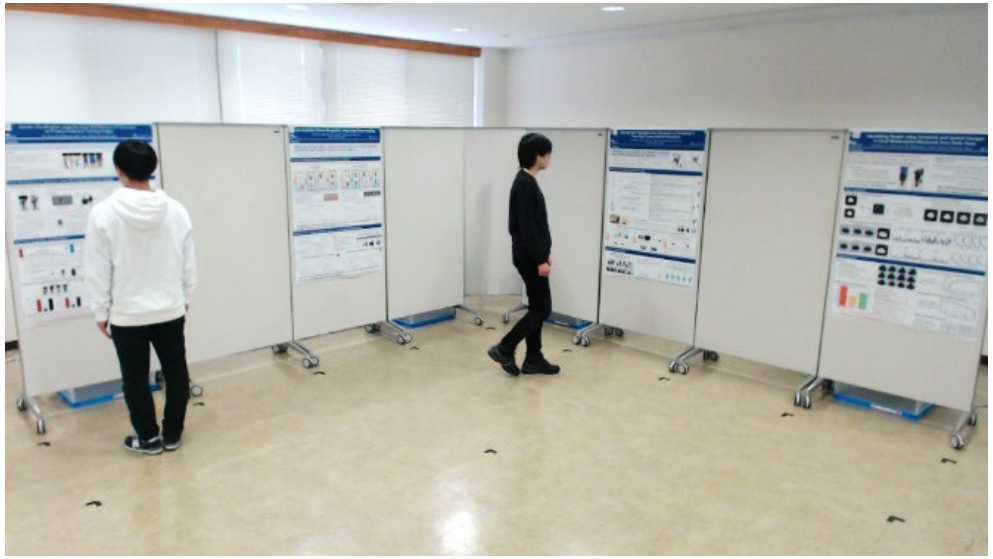
Introduction

There is a demand for technologies to estimate a person's position in public spaces.

Cameras that can image large spaces with high spatial resolution are commonly used as sensors to estimate an individual person's position.



Camera



Without temporary shielding



With temporary shielding

However, the camera's field of view may sometimes be blocked by objects that have been placed temporarily.

Wireless devices as sensors

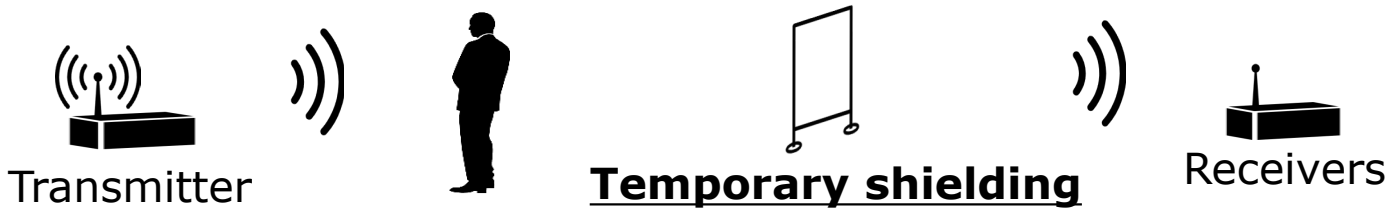
We consider whether there is a sensor configuration that can estimate a person's position stably even when temporary shielding is placed.

Wireless sensing uses radio waves, which may provide information even when the camera view is blocked.

Existing methods using wireless devices

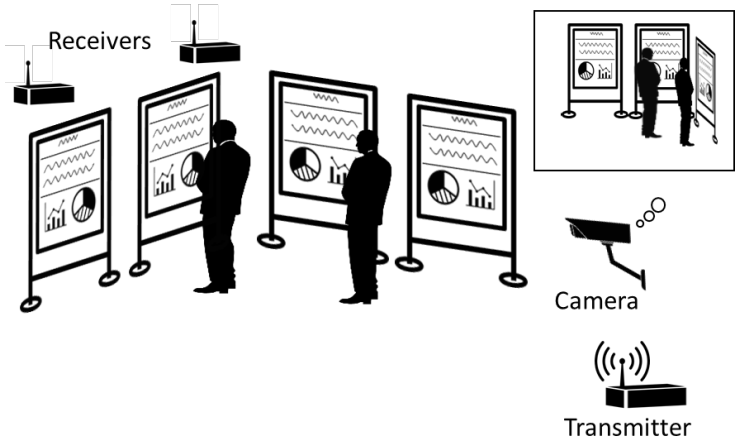
- Person position estimation (Youssef et al., 2007; Booranawong et al., 2019)
- Body shape and posture estimation (Xue et al., 2021; Wang et al., 2023)

This motivates us to evaluate wireless sensing for person position estimation under temporary shielding.

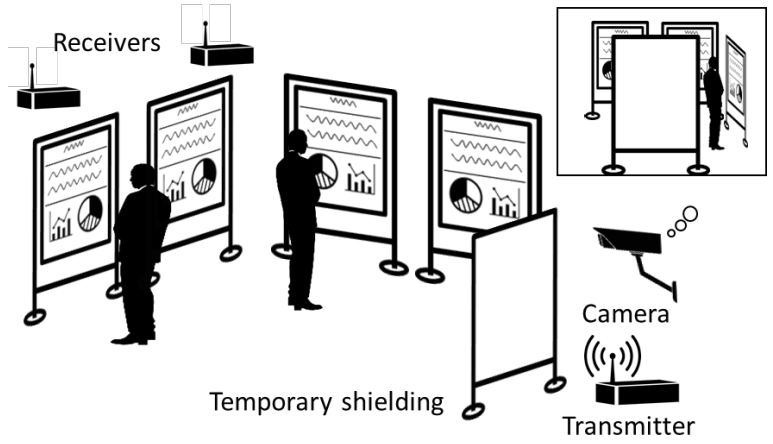


Previous Work: RSSI-Based Position Estimation

Our previous method [1] uses camera images to collect training data and estimates person positions from **RSSI time-series signals** during temporary shielding.



Without temporary shielding
(Training phase)



With temporary shielding
(Inference phase)

RSSI: Received Signal Strength Indicator

Position estimation under temporary shielding
Best results among the evaluated regression models

Walking Persons	Model	Error [cm]
One	RF	**12.4 ± 3.8**
Two	*k*NN	**18.7 ± 6.6**

Mean ± standard deviation, with RSSI preprocessing.

These results show that RSSI can be used to estimate positions during temporary shielding.

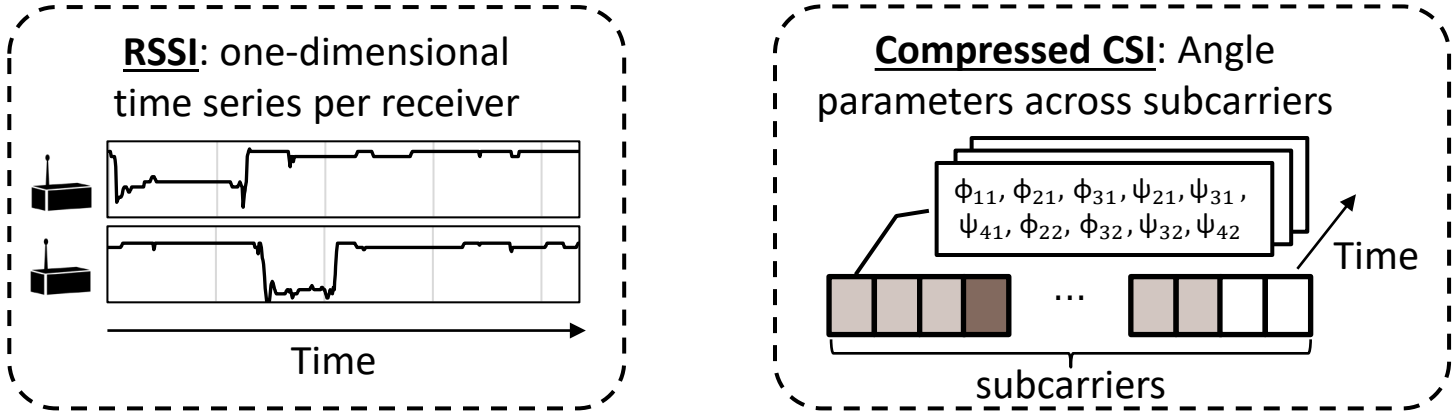
RSSI limitation: Received power alone does not capture detailed propagation differences.

Motivation: Richer wireless information may help distinguish person positions.

[1] Y. Makimura et al., VISAPP 2026, vol. 2, pp. 259–266.
"Estimating person positions using a camera and wireless devices in a space with temporary shielding"

Motivation for Using Compressed CSI

In addition to RSSI, Wi-Fi signals provide channel state information (CSI).



CSI provides propagation information across subcarriers and antenna pairs.
CSI has been investigated for human detection and indoor localization.

(Wang et al., 2021; Miyazaki et al., 2019; Yang et al., 2022)

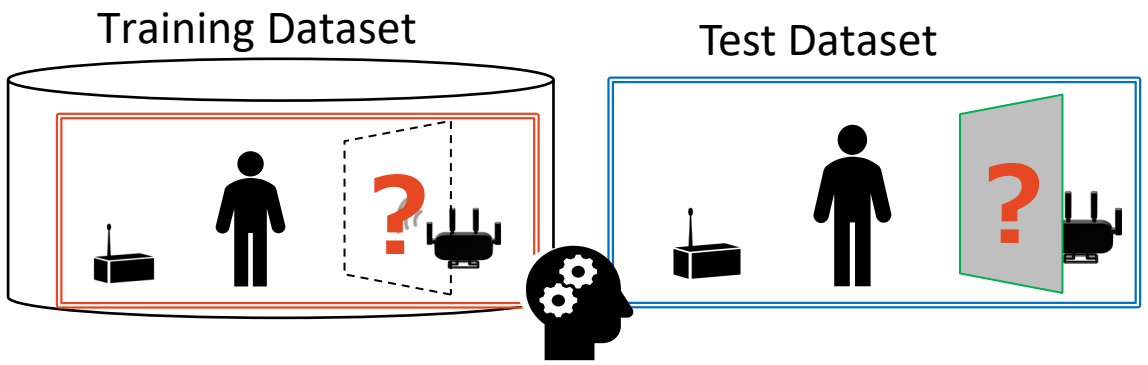
Obtaining raw CSI often requires specific devices or tools.
We therefore focus on compressed CSI used for beamforming feedback in IEEE 802.11ac/ax.

Compressed CSI remains insufficiently evaluated for person position estimation under temporary shielding.

Research Objective

We evaluate the accuracy of person position estimation using compressed CSI in an environment with temporary shielding.

Training and test conditions

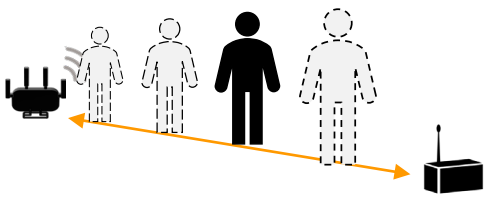


Shielding condition: Matched / Mismatched

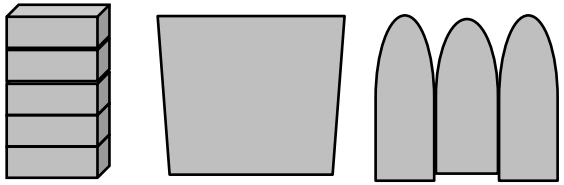
Recording date: Same day / Different days

Environmental conditions

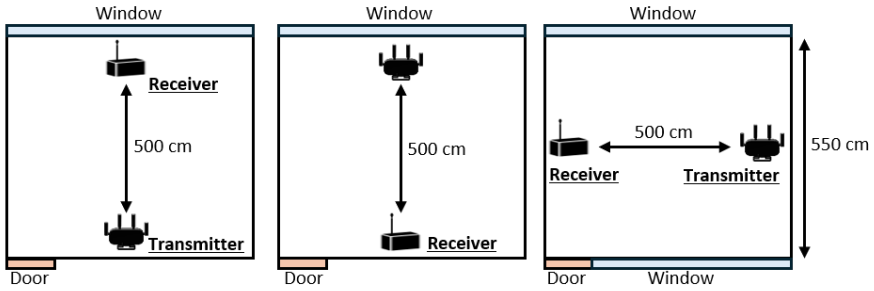
Person position



Occluder type



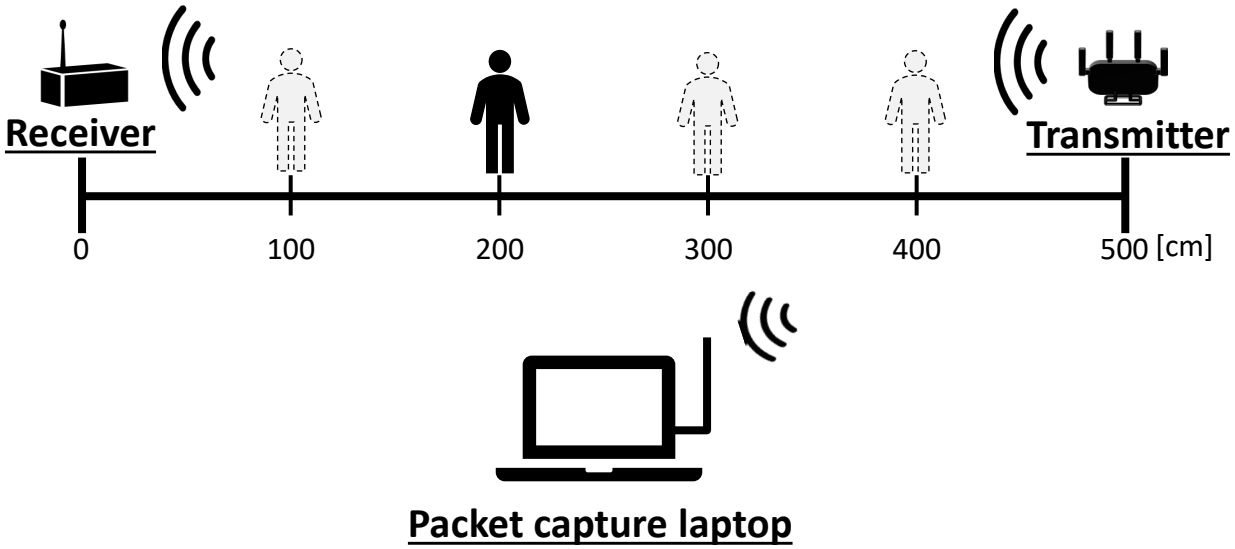
Room layout



We examine how training and test conditions and environmental conditions affect estimation accuracy.

Experimental Setup

We collected compressed CSI while a single participant carrying no wireless device stood still at predefined positions between the transmitter and receiver.



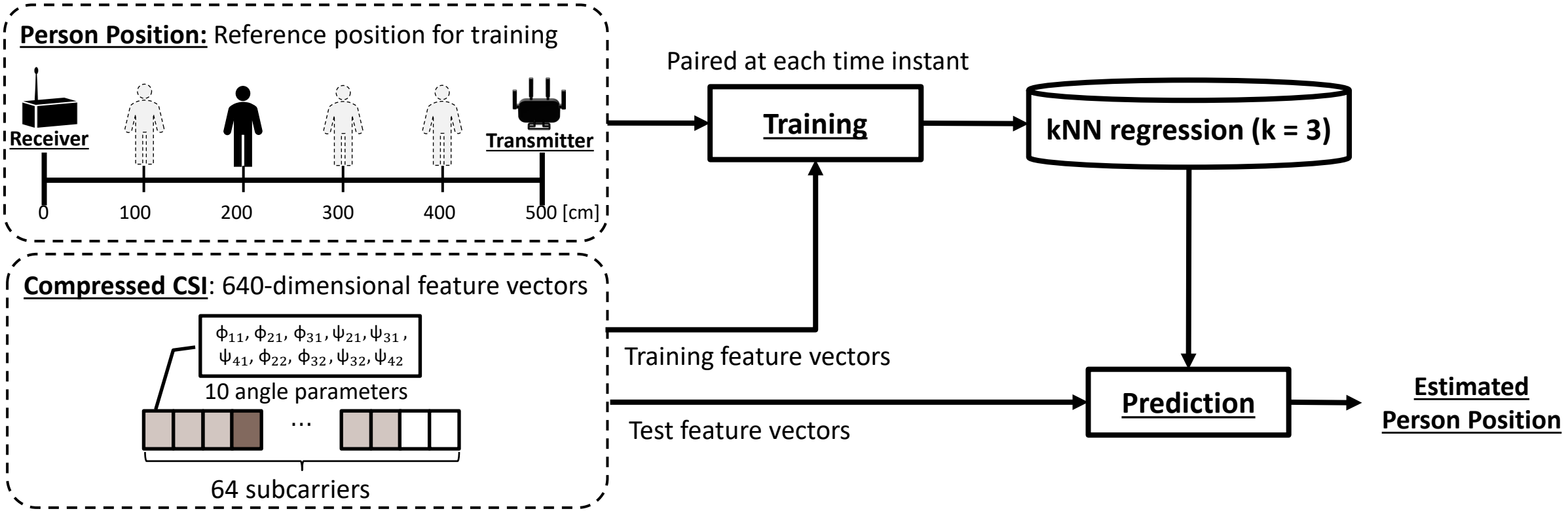
Frequency band	5 GHz
Beamforming	Enabled
Recording duration	10 s × 5 trials per condition
Mean capture rate	9.2 packets/s
Packet capture	Wireshark
Device height	70 cm

A separate laptop captured the beamforming feedback packets using Wireshark.

Each compressed CSI sample was paired with the corresponding predefined person position.

Person Position Estimation Using Compressed CSI

We use the collected compressed CSI to construct feature vectors and estimate person positions using *k*NN regression.



We select the three nearest training samples using Euclidean distance in the feature space and average their positions.

Evaluation Conditions

We evaluated position estimation accuracy under different training, test, and environmental conditions.

Training and Test Conditions

L1: Shielding (training → test):

No → No / Yes → Yes / No → Yes / Yes → No

L2: Training/test data collection: Same day / Different days

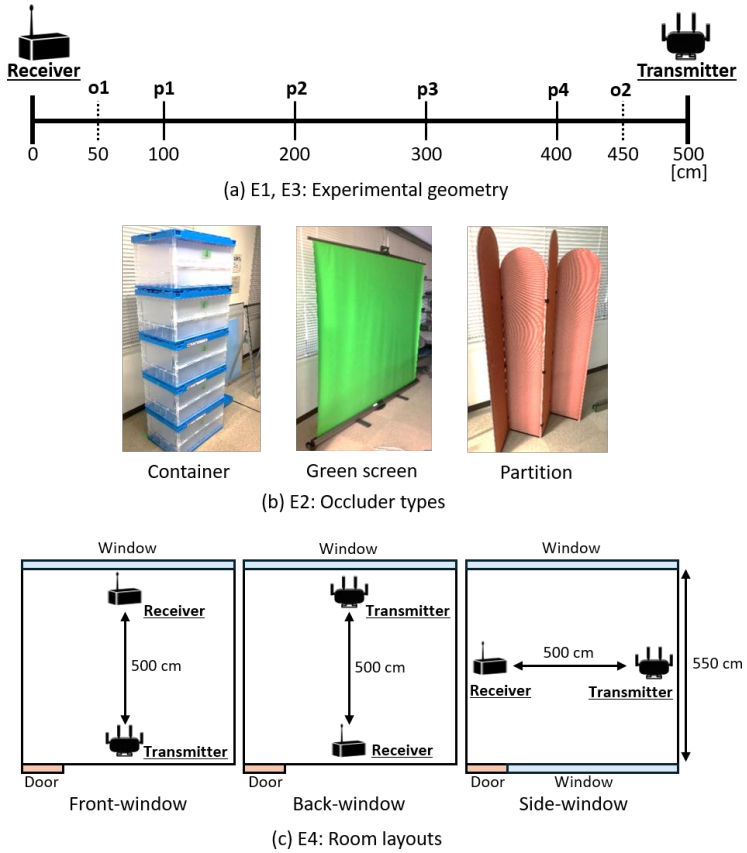
Environmental Conditions

E1: Person position: Four positions (p_1–p_4)

E2: Shielding object: Three types

E3: Shielding position: Two positions (o_1, o_2)

E4: Device placement relative to windows: Three layouts

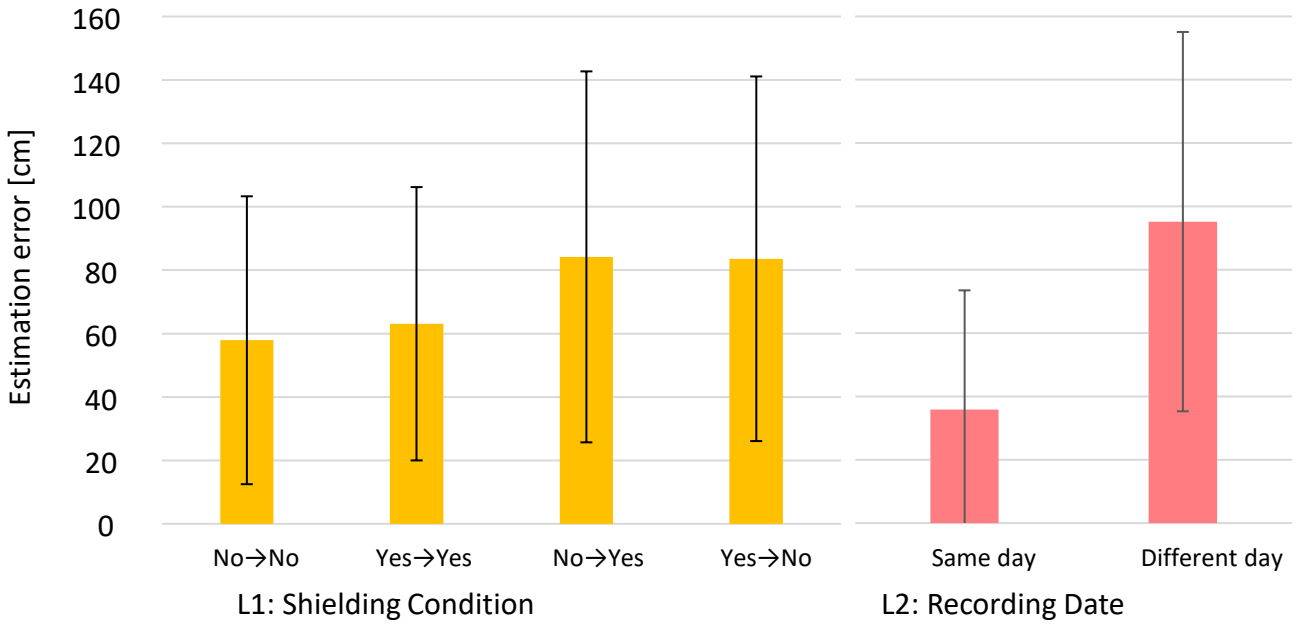


Position error is the Euclidean distance between the estimated and reference positions.

Results are reported as the mean and standard deviation of the position error.

Results: Training and Test Conditions

We examined the effects of shielding conditions and recording dates on position error.



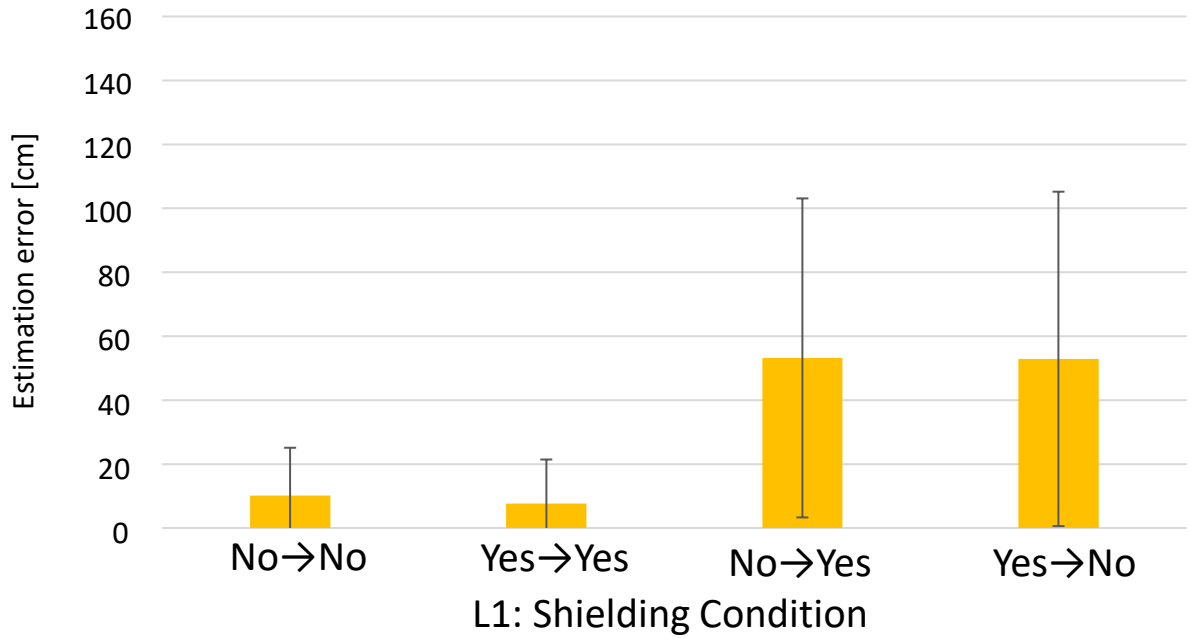
The yellow bars compare shielding conditions and include both same-day and different-day data.

Mean errors were 60.5 cm for matched shielding conditions and 83.9 cm for mismatched conditions.

Mean errors were 35.9 cm for same-day data and 95.2 cm for different-day data.

Results: Shielding Conditions on the Same Day

We compared shielding combinations using only same-day training and test data.



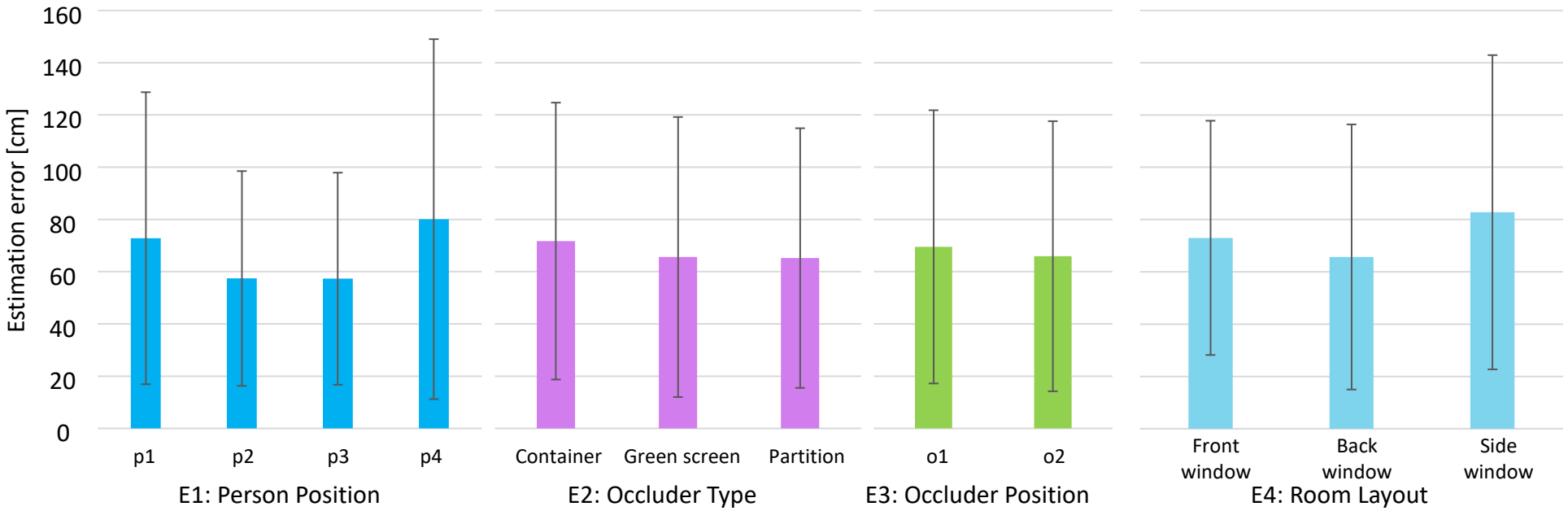
Training → Test / Error bars: Standard deviation

Mean errors were below 11 cm when shielding conditions matched, but approximately 53 cm when they differed.

Low error was achieved even with shielding when the training and test conditions matched.

Results: Environmental Conditions

We compared position errors across the four environmental factors.



	Range of mean error (max – min)
E1	**22.8 cm**
E2	**6.5 cm**
E3	**3.6 cm**
E4	**17.1 cm**

Results include both same-day and different-day data.

The ranges were larger for person position and device layout.

However, the standard deviations were large, so further evaluation is needed.

Conclusions

We evaluated the accuracy of person position estimation using compressed CSI under different shielding and data collection conditions.

With same-day data and matching shielding conditions, mean errors were below 11 cm, even with shielding.

However, in our target case (No → Yes), the mean error was 53.2 cm even with same-day data.

Shielding may change compressed CSI features, creating a difference between training and test data.

Future work

We explore feature normalization and calibration to reduce these effects.
We compare RSSI and compressed CSI under the same experimental conditions.