NEURAL INFORMATION PROCESSING SYSTEMS

AmbientFM: A Foundation Model for Ambient Sensing

Guozhen Zhu[1], Yuqian Hu[1] , Sakila S Jayaweera[1] , Wei-Hsiang Wang[1] , Weihang Gao[1] ,
Jiaxuan Zhang[1] , Beibei Wang[1] , Chenshu Wu[2] , K. J. Ray Liu[1]

[1]ADT Research [2]University of Hong Kong

Presenter: Guozhen Zhu
Email: gzzhu@terpmail.umd.edu
Project page:

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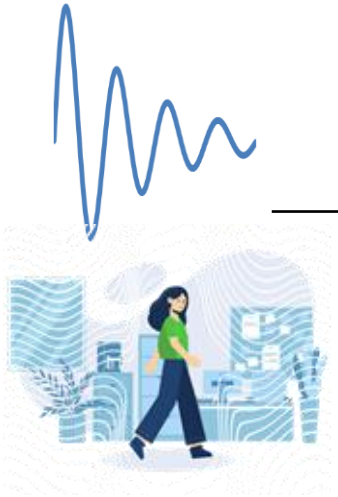
Ambient Intelligence with wireless signals



Feature Extraction

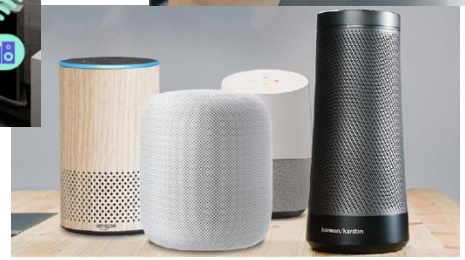
Monitoring:
Who (Identification**)**
What (Recognition**)**
Where (Localization**)**
When (Detection**)**

Applications:
Indoor tracking,
Breathing detection,
Human activity recognition,
Gait recognition,
Human identification,
People counting

Contributes to:
Smart home
Security
Location-based Services
Tracking
Health care
Smart Buildings
Augmented Reality



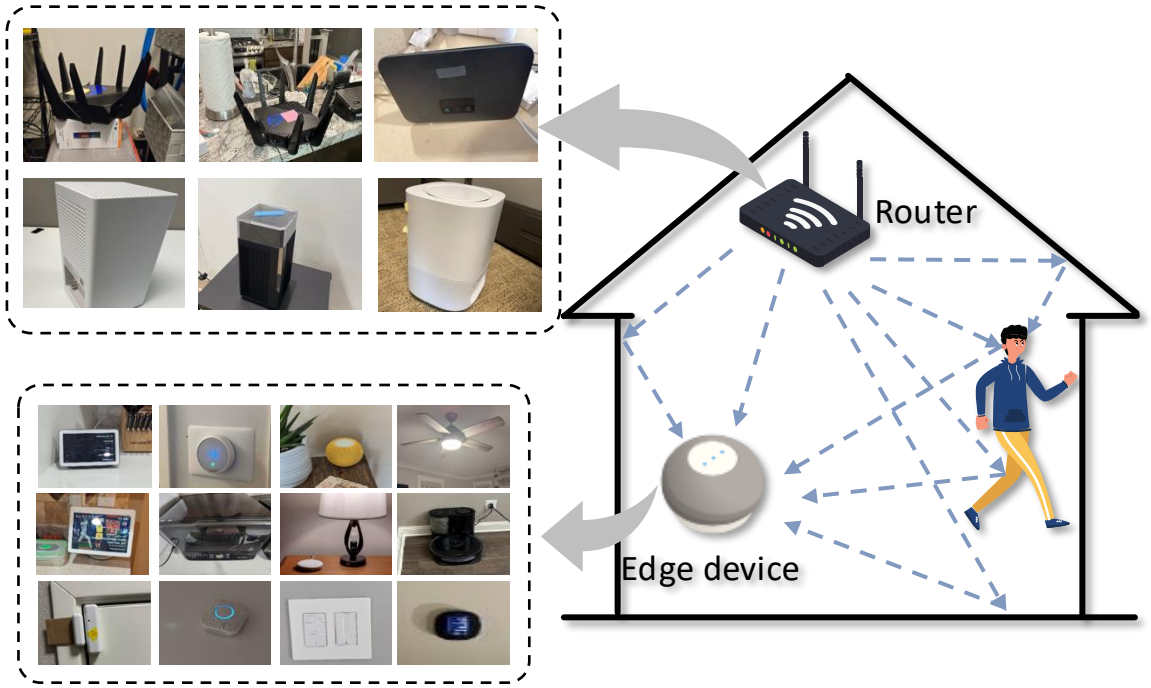






Dataset





9.2 million Data samples

439 Days

20 Device types

11 Environments

8 Chipset families

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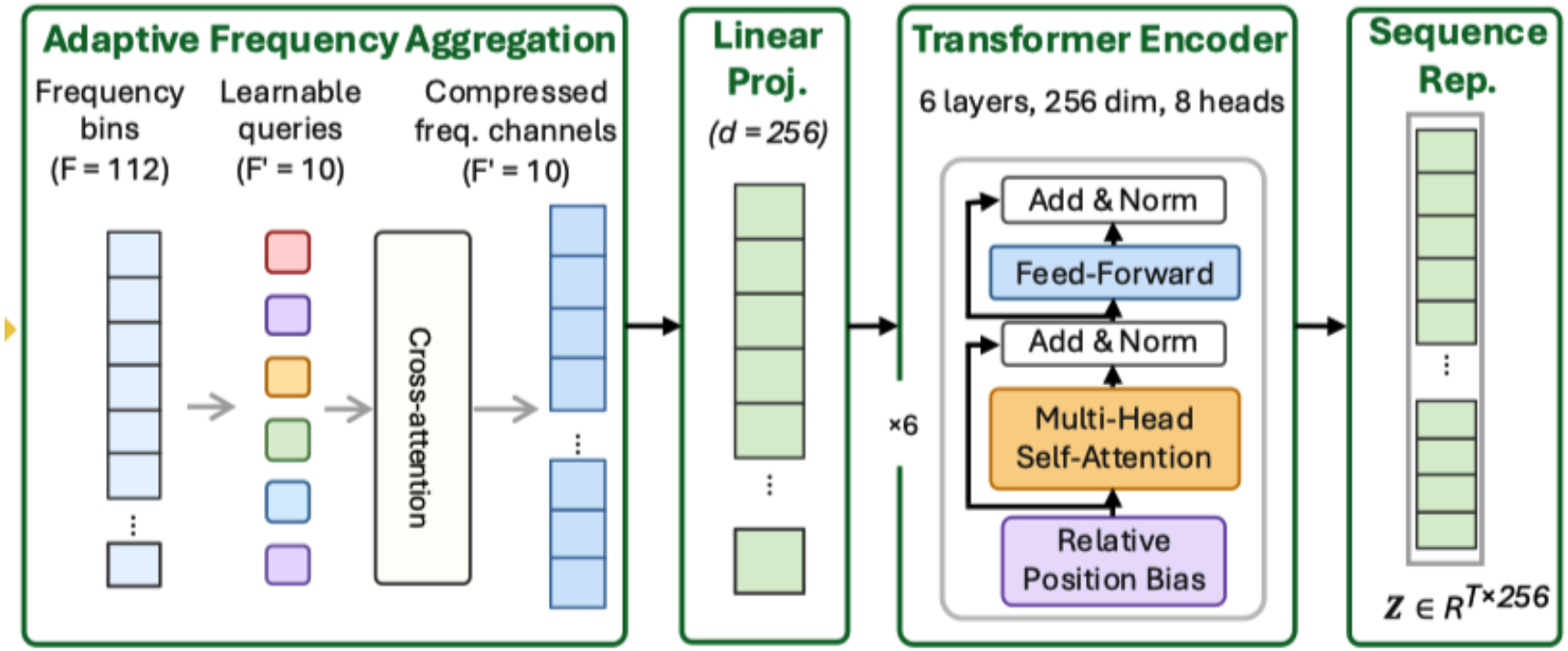
Model Architecture



Unequal subcarrier quality and nonlocal correlations → Adaptive frequency aggregation

The same activity can occur anywhere in a window → Relative offsets

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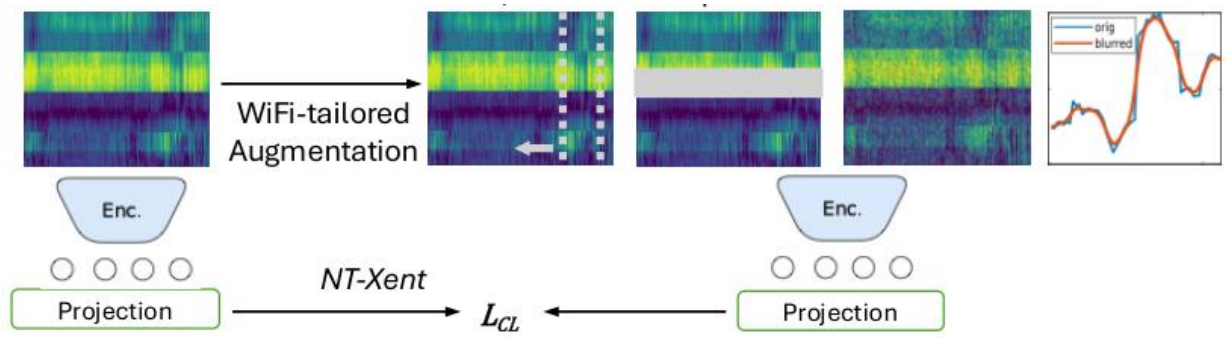
Training objectives tailored to CSI

Wireless perturbations

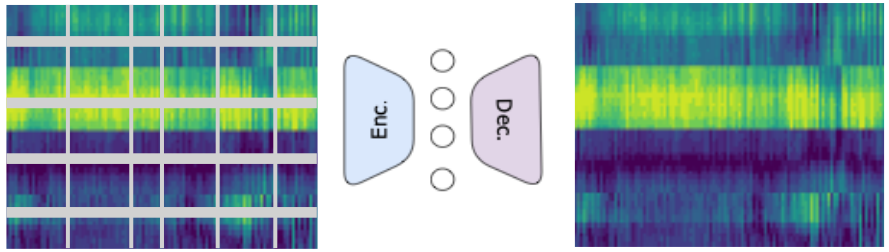
Contrastive learning



Consistency across realistic wireless variations

Missing time / frequency data

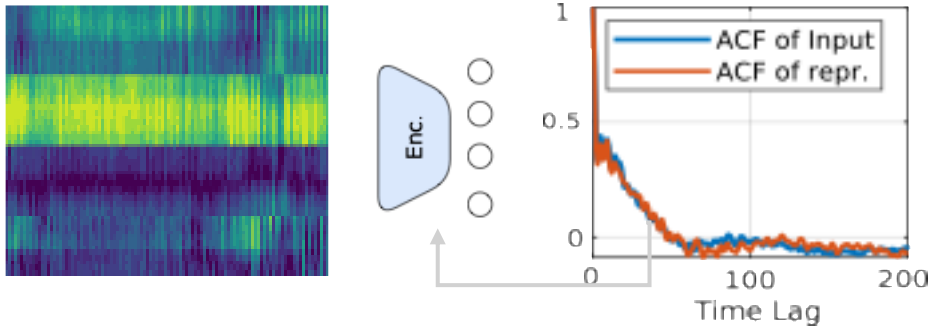
Masked reconstruction



Temporal coherence and cross-frequency structure

Motion-related dynamics

Autocorrelation prediction



Temporal patterns in CSI energy

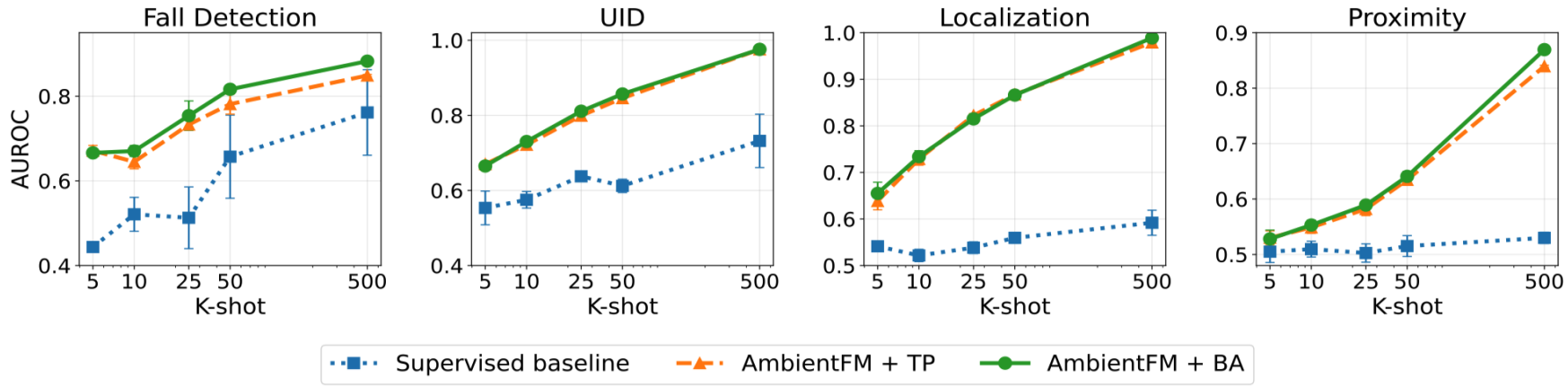
Evaluation

Downstream Evaluation

AUROC	Fall	Activity	Gesture	User ID	Location	Motion source	Occupancy	Proximity
From scratch	.916	.527	.564	.995	.631	.593	.566	.494
Temporal probe	.873	.915	.634	.996	.990	.992	.989	.928
With adapters	**.919**	**.923**	**.999**	**.993**	**.995**	**.974**	**.989**	**.936**

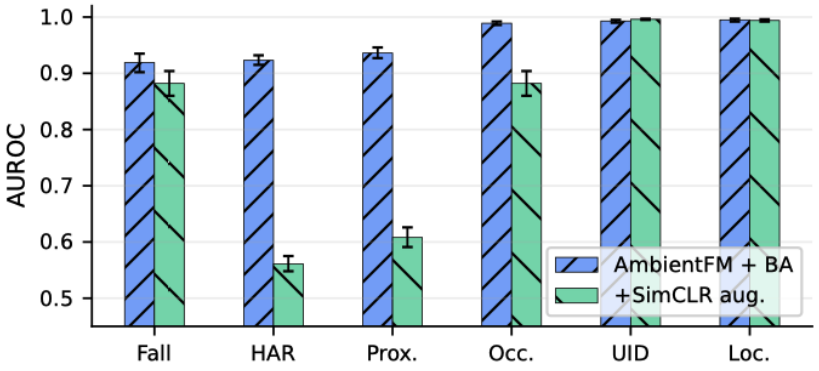
Frozen features transfer broadly; adapters help fine-grained gestures

Label Efficiency

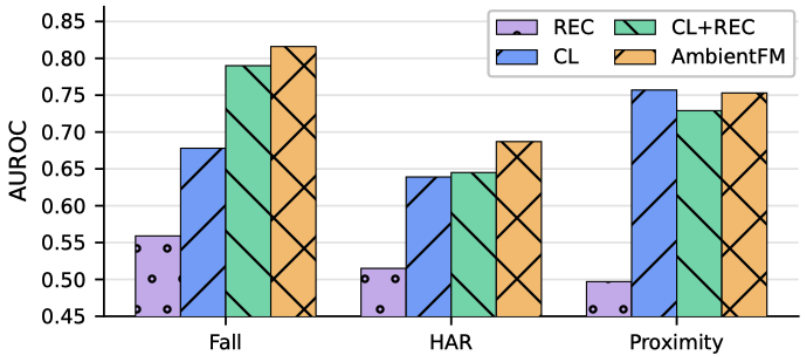


Useful wireless representations reduce the burden of downstream labeling

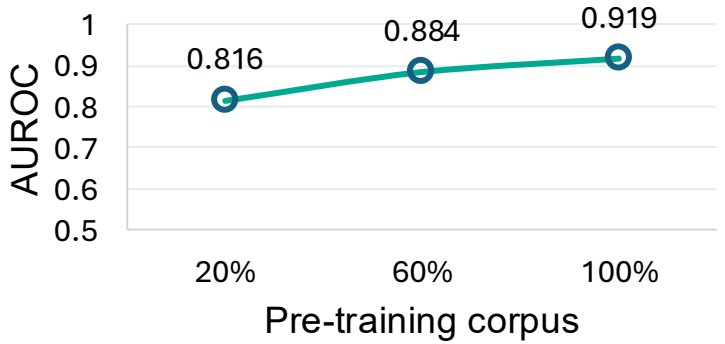
Evaluation



Wireless augmentations preserve sensing information



Complementary losses improve transfer



More pre-training data improves transfer

Distance	Fall	Loc.	UID	Prox.	HAR	MSR
Pre-trained	3.61	4.12	5.16	3.64	1.57	2.58
Random init	0.25	0.24	0.21	0.14	0.03	0.12
Ratio (×)	**14.4**	**17.4**	**24.2**	**26.5**	**52.0**	**21.0**

Mean per-task ratio: 25.9×

Pre-training separates task-relevant classes

Thank you



https://ai-sensing.github.io/ambient-fm/index.html