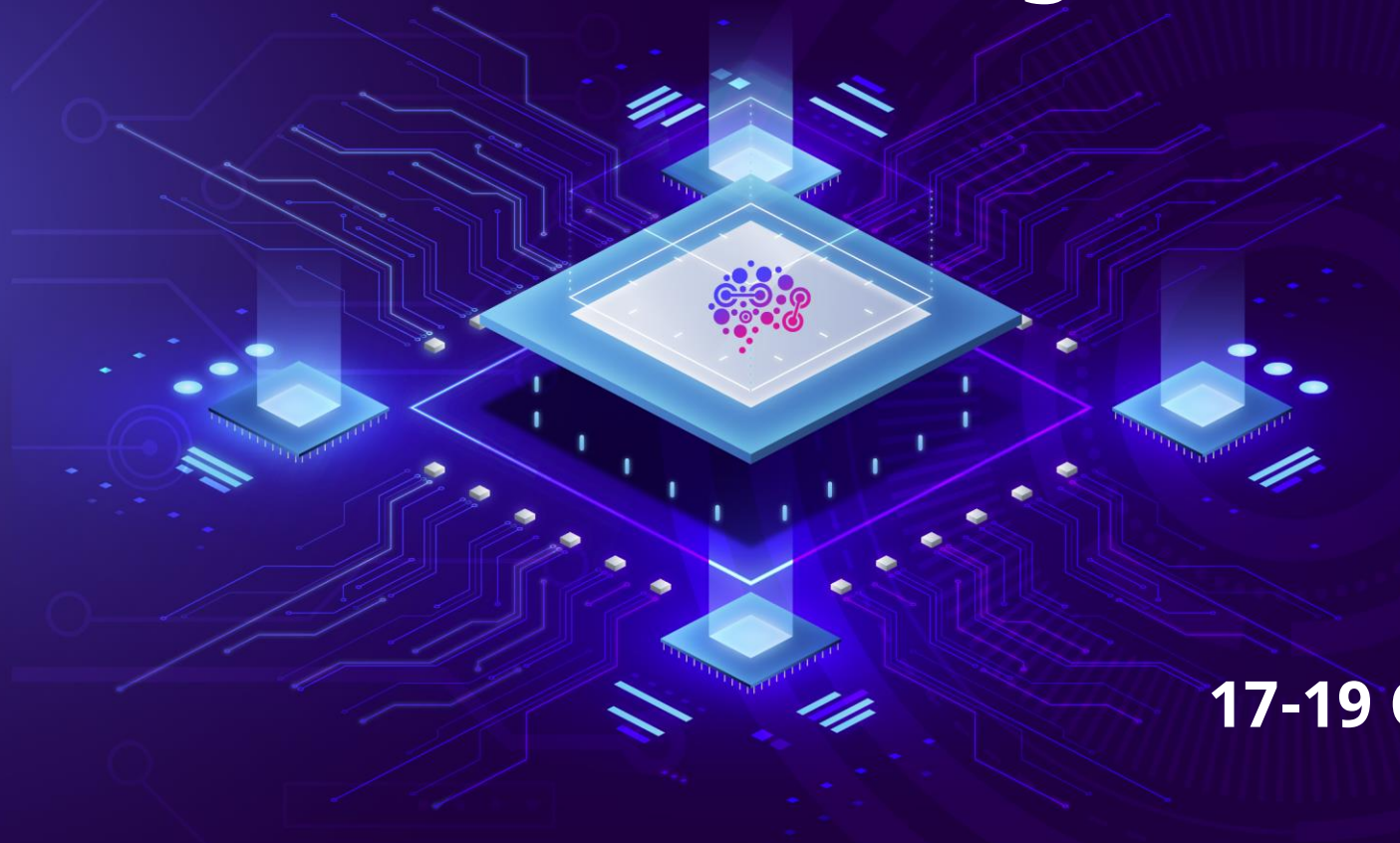
European Conference on EDGE AI Technologies and Applications - EEAI



Advancing emerging edge AI technologies and driving next generation intelligent applications.

17-19 October 2023, Athens, Greece

European Conference on EDGE AI Technologies and Applications - EEAI

RANet: An Autoencoder for High-Resolution Range-Angle Maps in Multistatic Radar

Chen Liu,
Technische Universität Dresden,
Germany

17-19 October 2023 Athens, Greece

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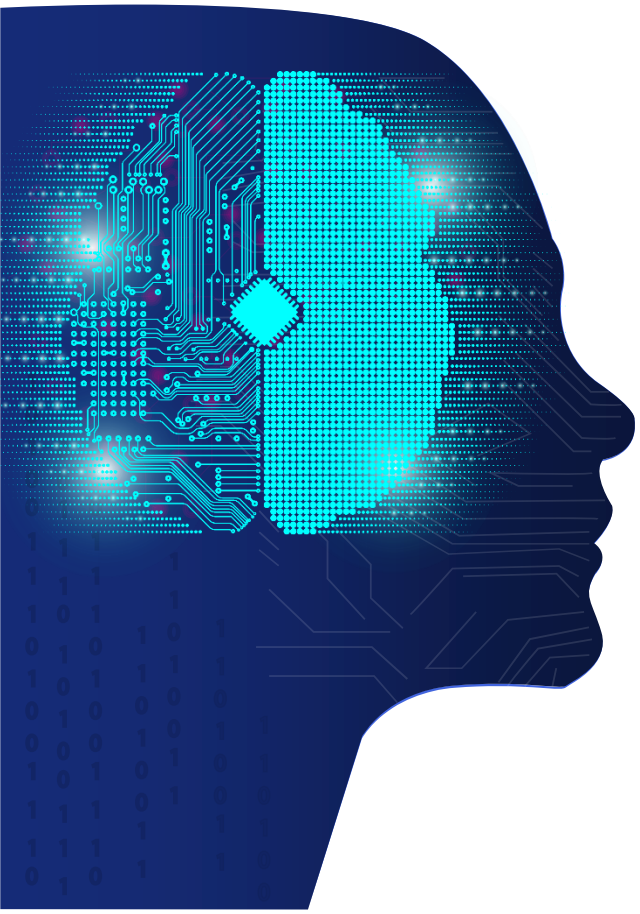
Presentation Outline



- Introduction
- State-of-the-art
- Research Goal
- Methodology
- Design and Implementation
- Experimental Results
- Future Research
- Conclusion

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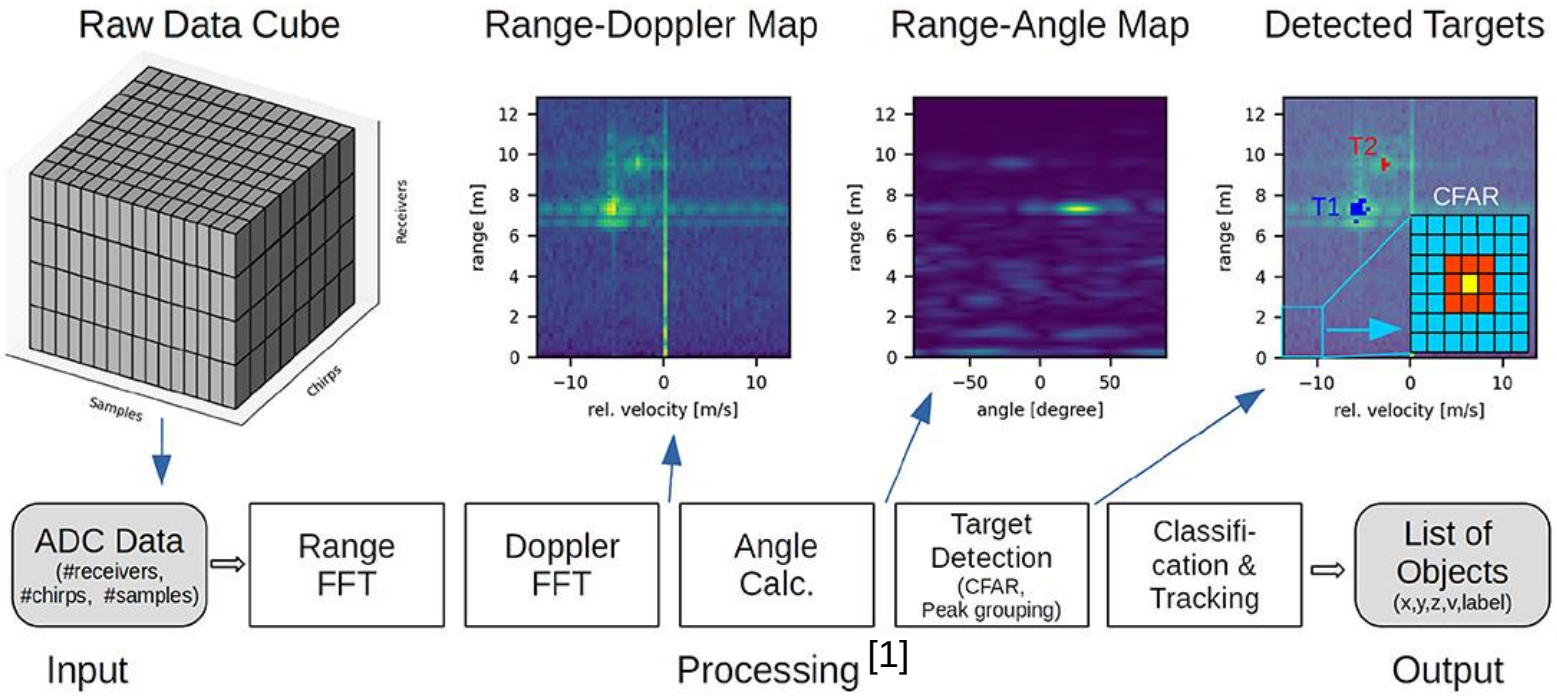
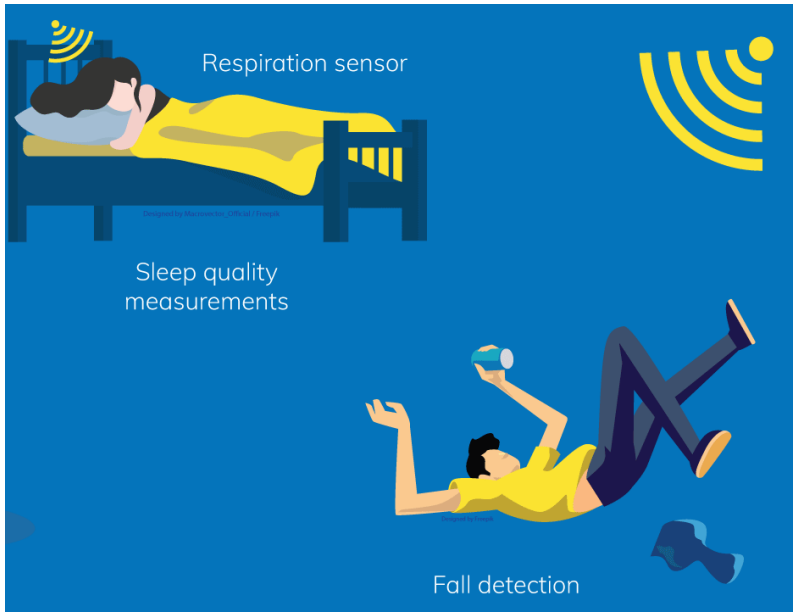
Introduction

- Radar is an alternative sensor to camera for indoor monitoring, such as respiration monitoring, fall detection.
- Prob.1: low angular resolution
- Prob.2: long processing chain





How to improve the radar imaging?

[1]: https://www.frontiersin.org/articles/10.3389/fnins.2022.851774/full

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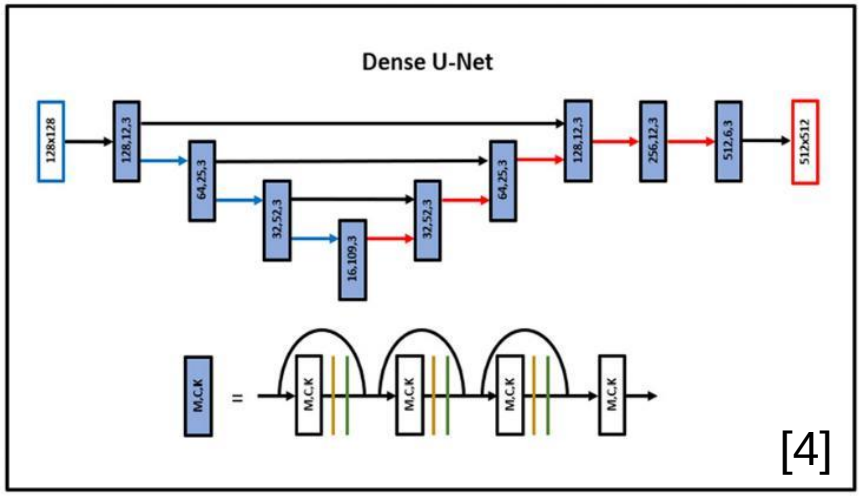
State-of-the-art

- Solve an undifferentiable L1 regularization problem
  - Split Bregmen algorithm (SBA) [2]
  - Superfast SBA [3]
- U-Net based super-resolution (CNN) [4][5][6]
- 4D imaging radar
  - Continental ARS640 (0.1°A, 0.1°E) [7]
  - Bosch front radar premium (0.1°) [8]
  - Renesas SRIR256V2 (0.1°A, 0.3°E) [9]



[4]

ARS640

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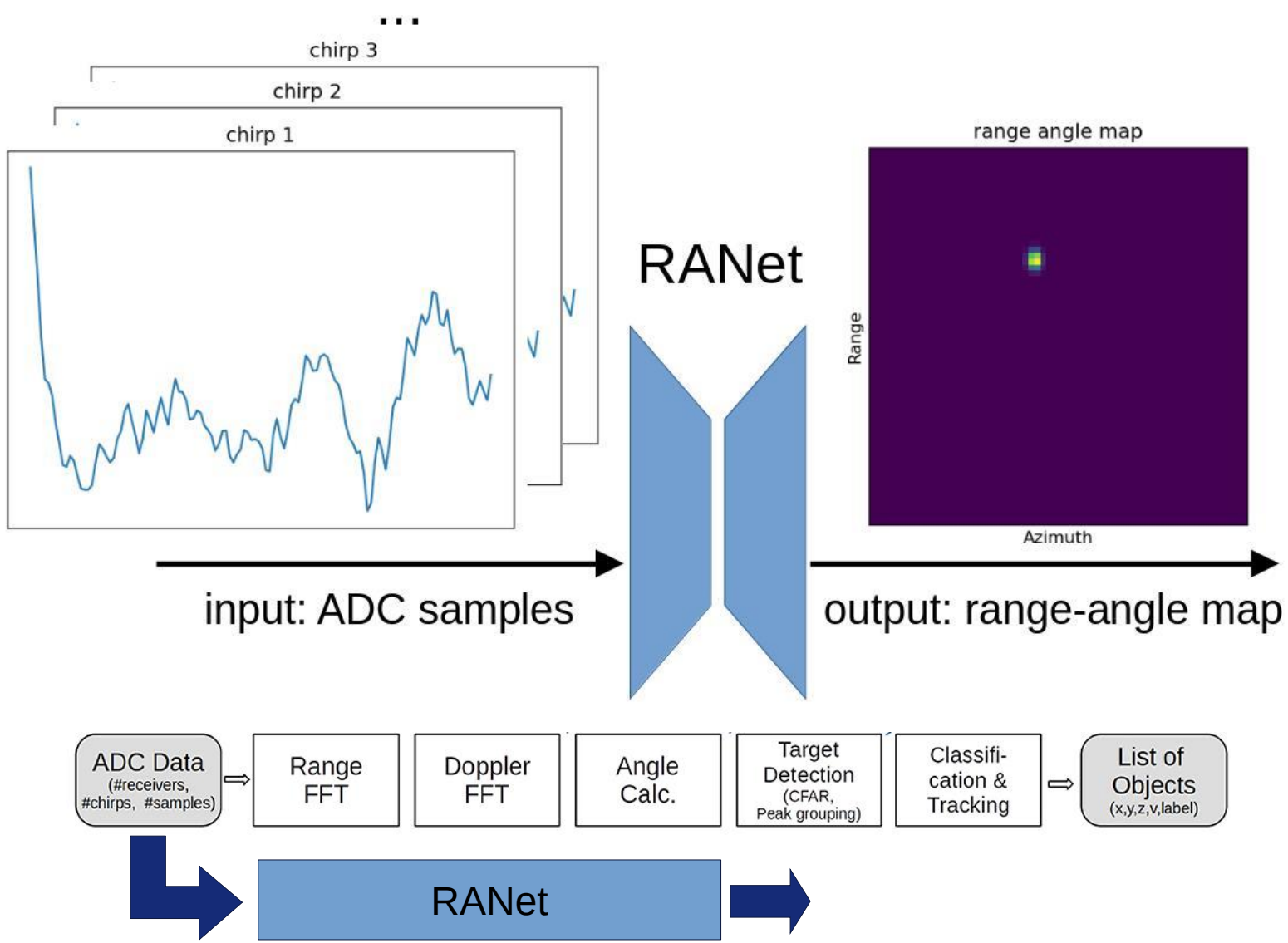
Research Goal

- Super-resolution radar imaging
- End-to-end DNN based prediction



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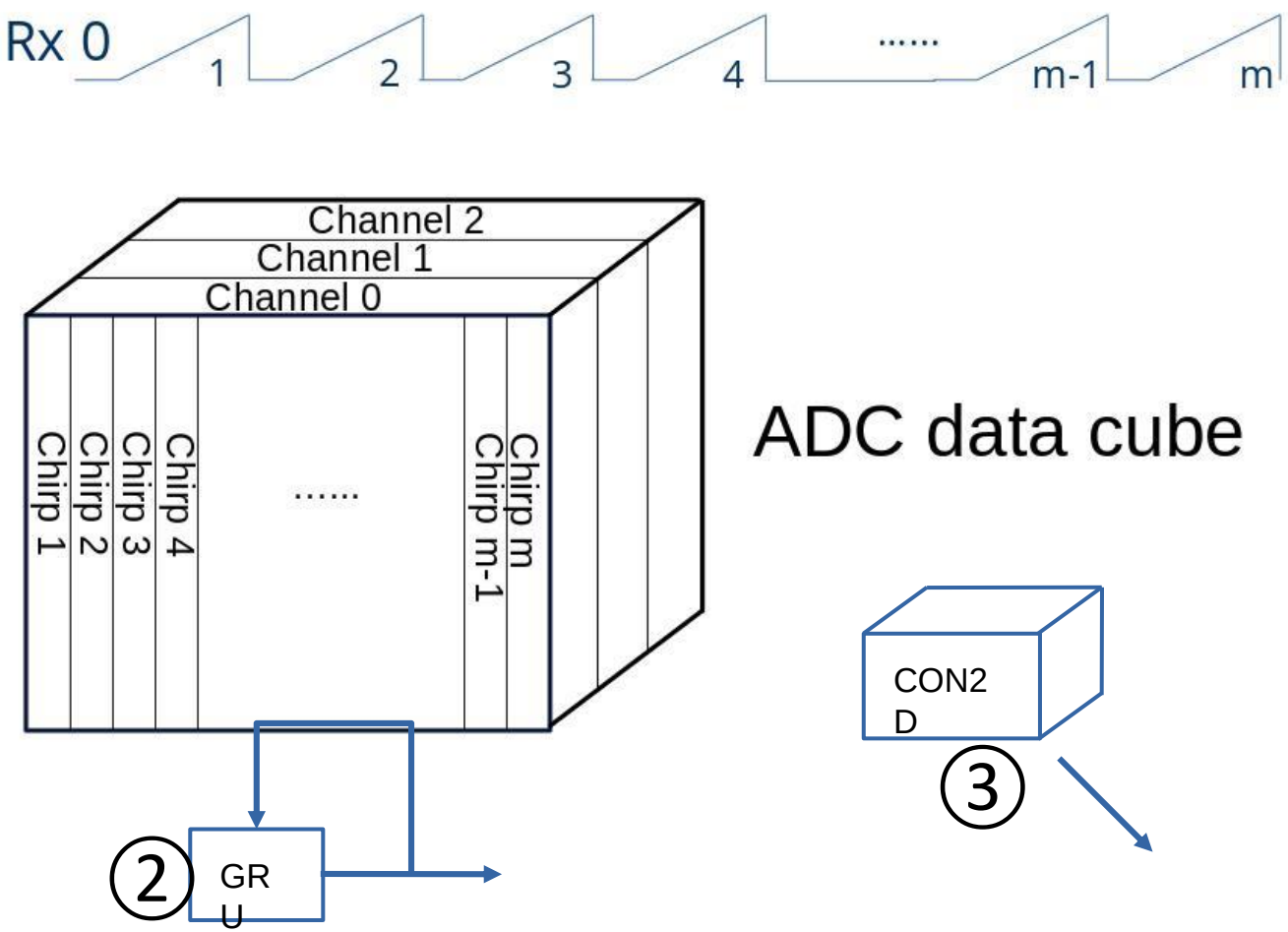
Methodology

- Autoencoder architecture
- A 3-stage DNN imitating conventional radar processing
  - CONV1D - range FFT
  - GRU - Doppler FFT
  - CONV2D - angle-FFT



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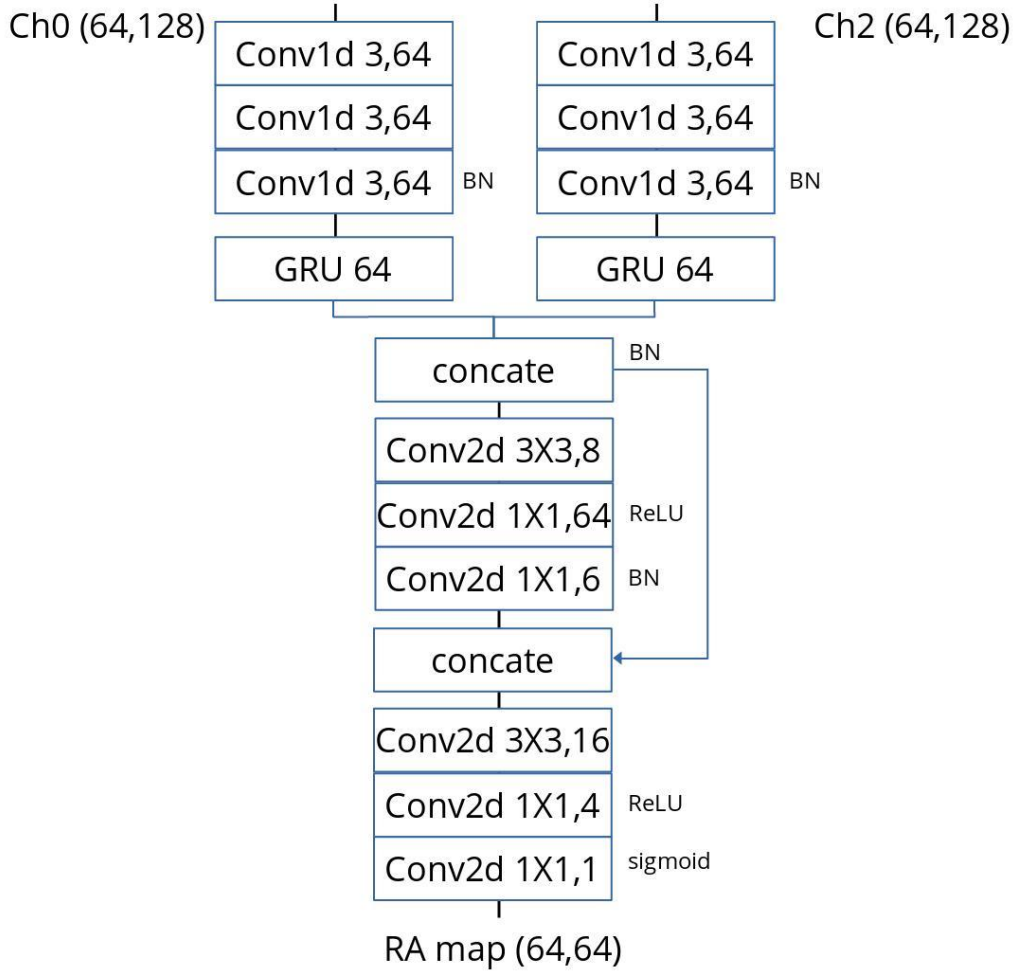
Design and Implementation

- Baseline model (1 sensor, 1 frame)
- Combine 2 azimuth channels
- Replace FC with conv2d by mixing local region and channels
- Model size: 149k parameters



Model structure

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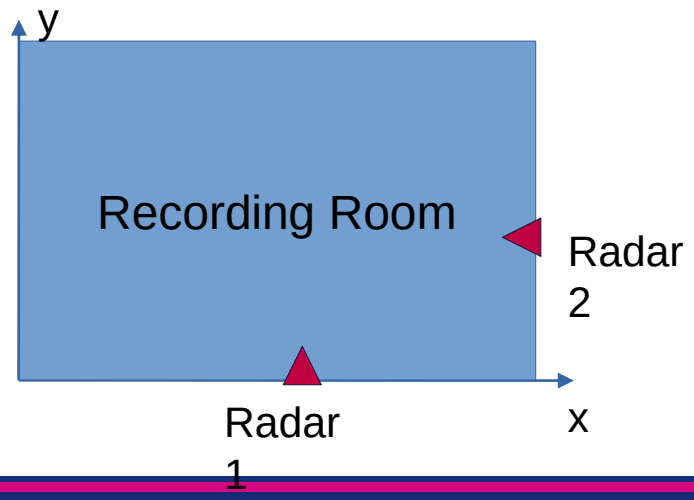
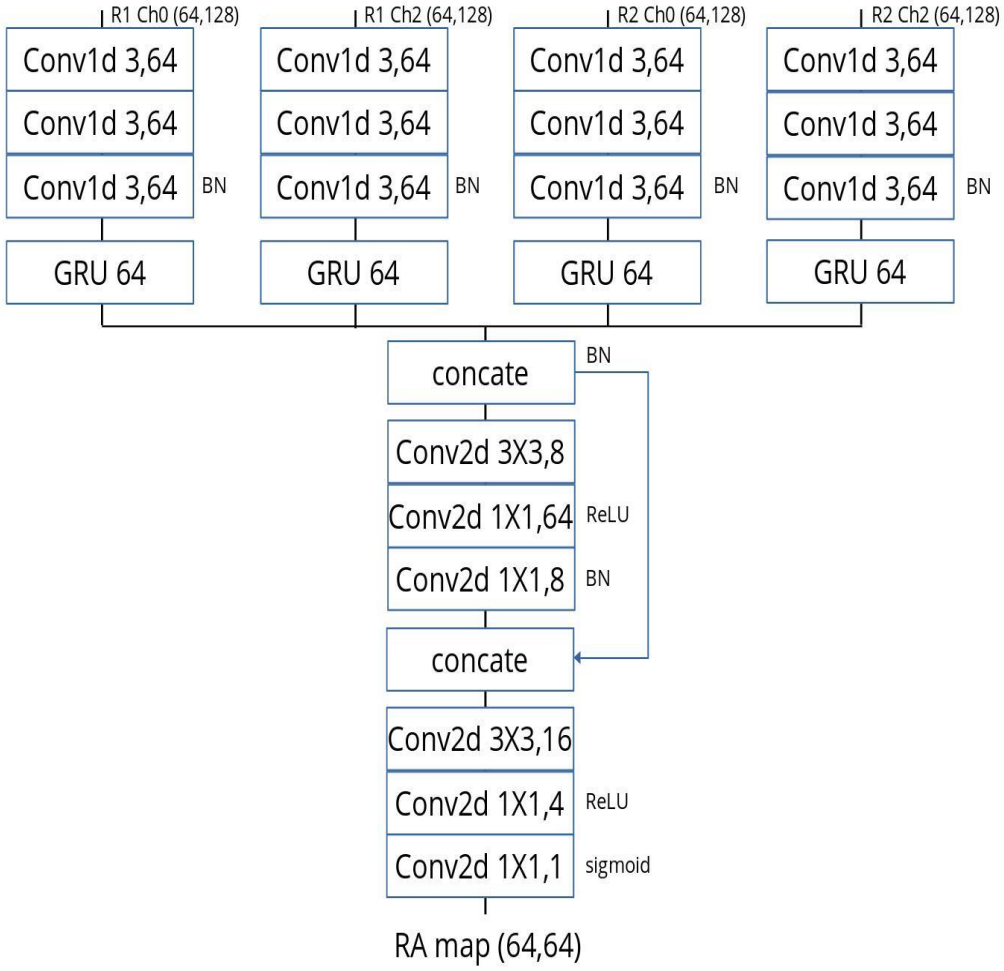
Design and Implementation

- Sensor fusion model
  (2 sensors, 1 frame)
- Combine 4 channels from 2 radars
- Ground truth radar image is the view from master radar
- Model size: 296k parameters





Model structure

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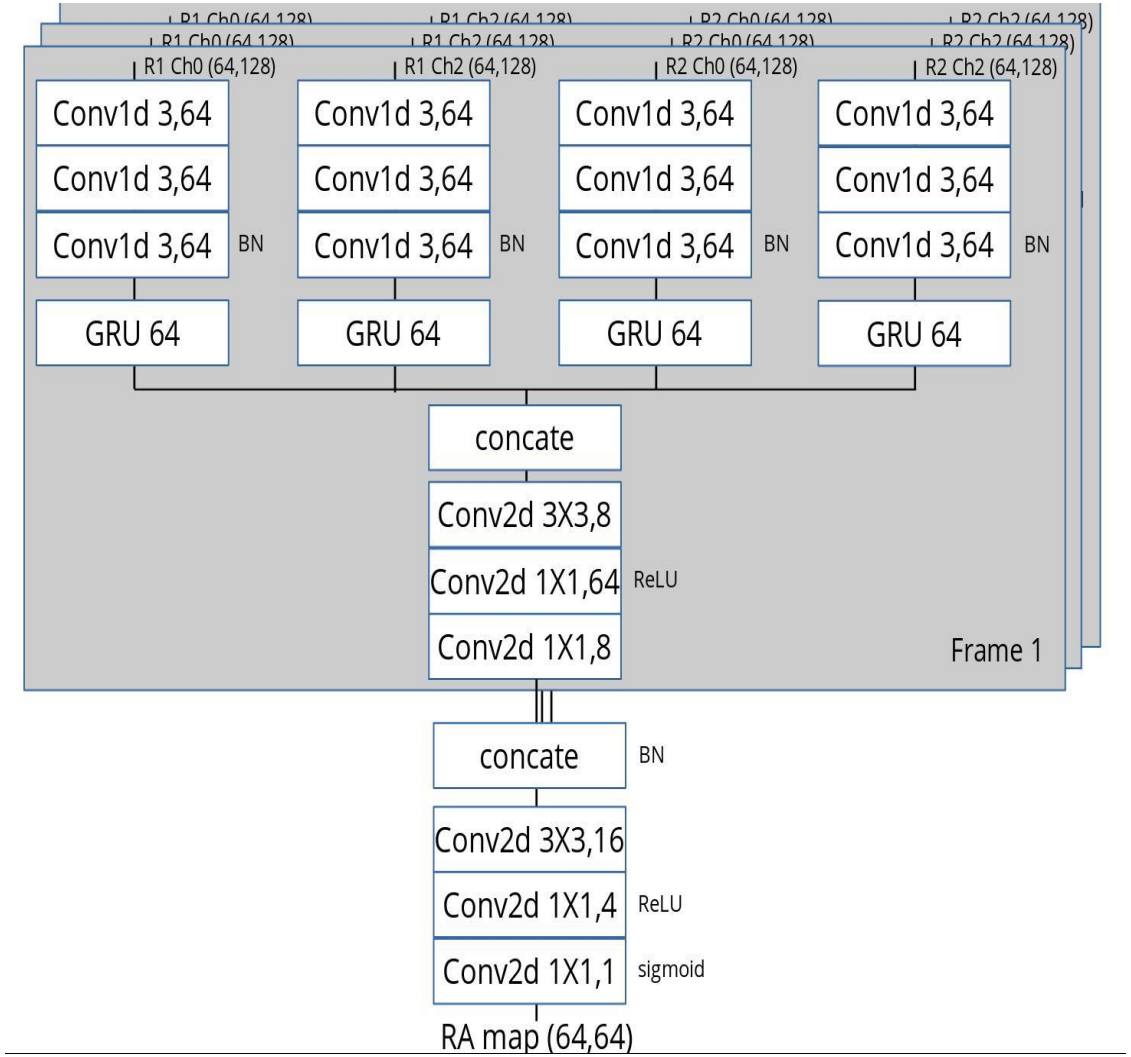
Design and Implementation

- Temporal-spatial fusion model
  (2 sensors, N frames)
- Combine N frames of 4 channels from 2 radars
- Model size: 298k parameters



Model structure

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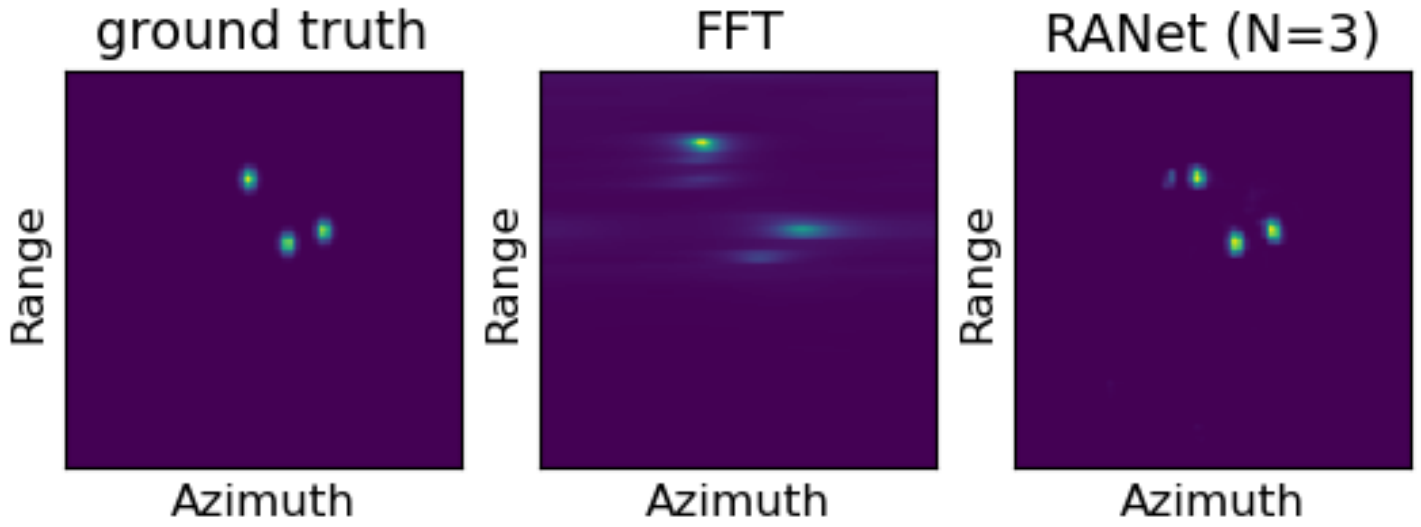
Experimental Results

- Accurate target prediction over FFT-based approach
- Optimum: temporal-spatial fusion with 2 frames



Visualized RA map comparison

Prediction quality comparison

Methods	MSE
Baseline	2.56
Sensor fusion	1.16
TS fusion (N=2)	**0.07**
TS fusion (N=3)	0.11
TS fusion (N=4)	0.14

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Experimental Results

- People counting: apply CFAR on predicted RA map and count

Methods	Baseline	Sensor Fusion	TS fusion (N=2)	TS fusion (N=3)	TS fusion (N=4)	TS fusion (N=7)
Accuracy	61.14%	83.23%	87.6%	90.6%	92.8%	96.4%

Condition: use Infineon's dataset [10] collected in project of Andante, false alarm rate of CFAR is 2.15%

- People tracking:

Scenarios	1 person	2 persons	3 persons	4 persons
Counting Accuracy	95.77%	92.81%	88.50%	83.67%
MOTA	99.97%	99.44%	99.88%	98.25%

[10]: https://link.springer.com/article/10.1007/s10489-023-04778-z

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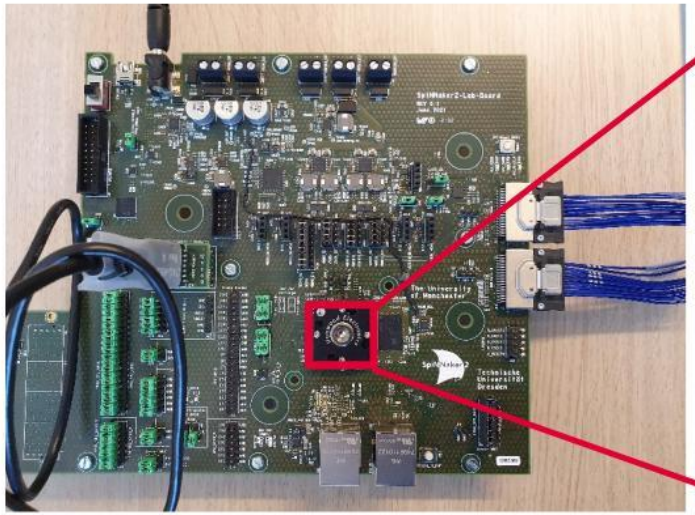
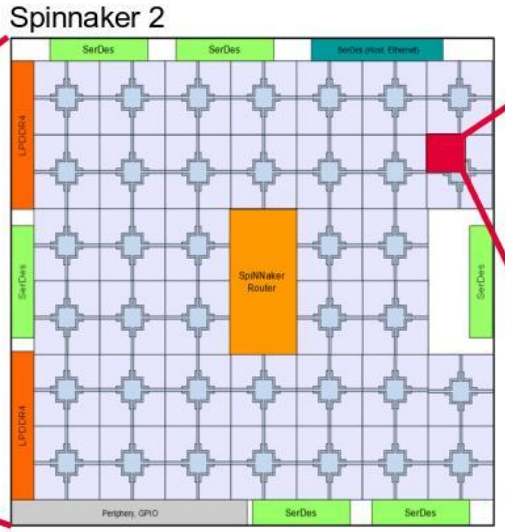
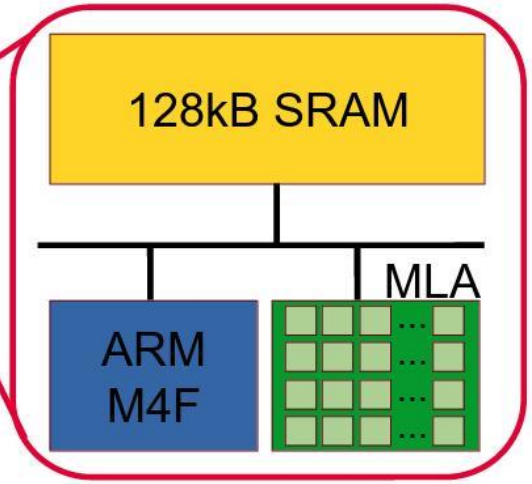
Future Research

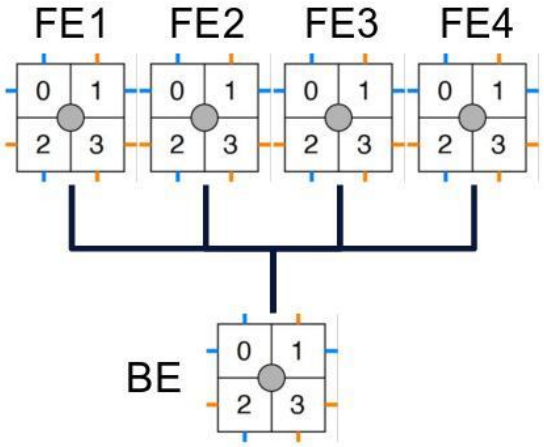
- Deploy the model into SpiNNaker2
- Compress model with quantization







MLA: Machine Learning Accelerator



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Conclusion

- Build an end to end DNN model predicting range angle maps
- Flexible structure applied to data of multiple frames and multiple sensors
- Super-resolution over conventional approach (e.g. FFT)
- Shorten the long radar processing chain
- Light-weight to be deployed in an edge device

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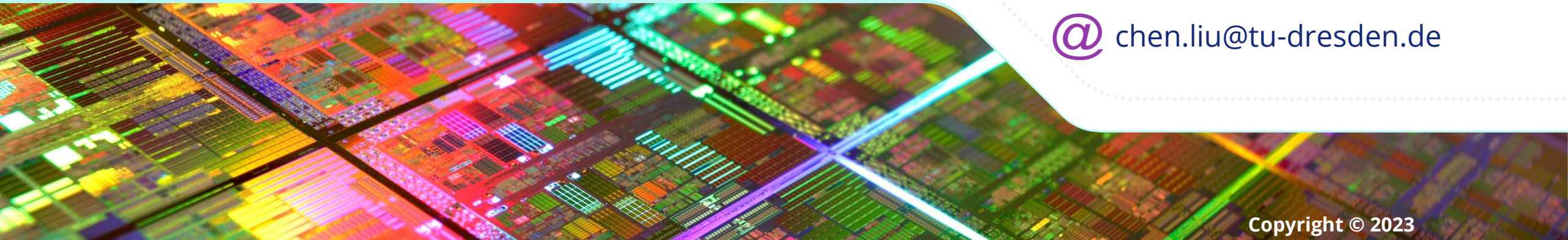
Thank You

For your attention



@ chen.liu@tu-dresden.de

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