Floor Localization

CS 435: Deep Learning
Course Project Final Presentation

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Outline

- Problem Statement
- SkyLoc
- Proposed model architecture
- Final model architecture
- Results
- Demo
- Team members contribution
- Remarks
- Future work

Problem Statement

- Create a floor localization system that can predict a user's floor depending only on cellular signals

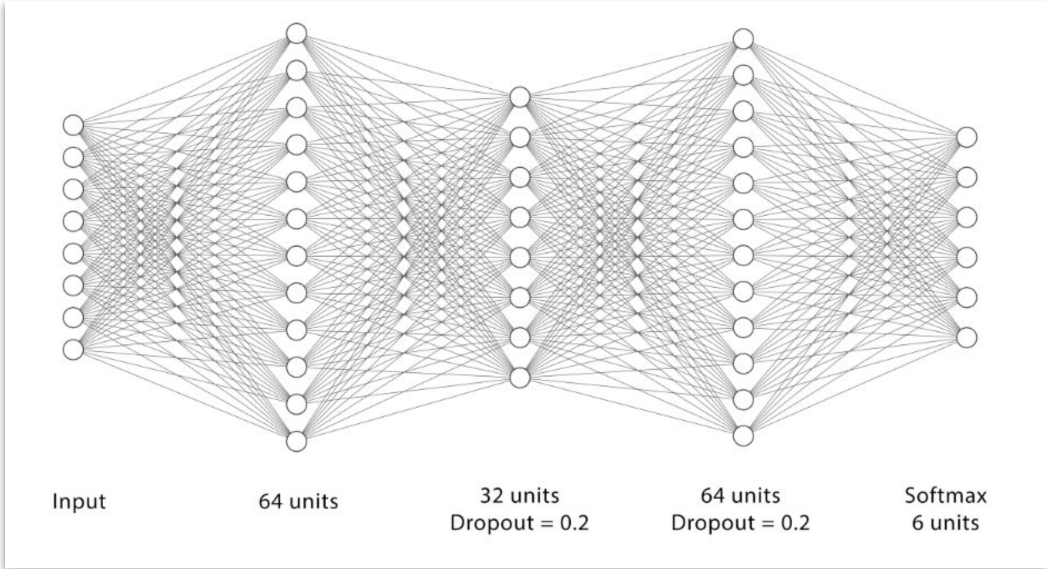
SkyLoc

- Calculates euclidean distance in RSS space from collected samples to estimate the floor of new samples

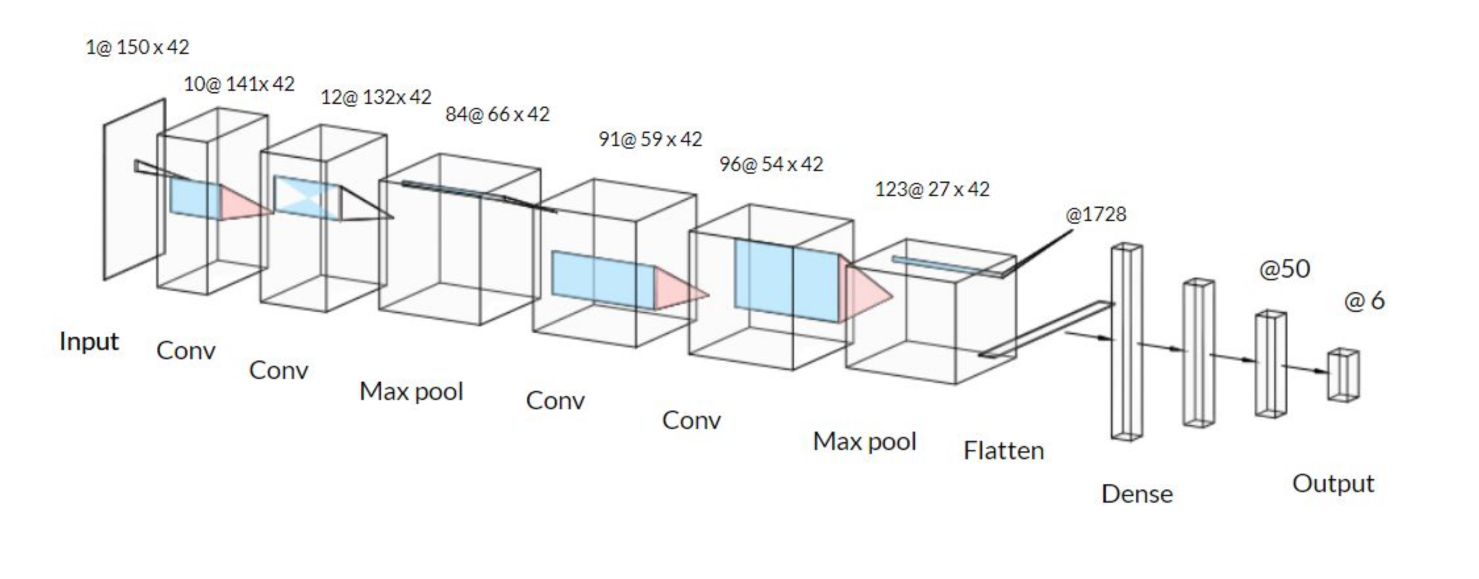
$$\sqrt{(R_1^{tr} - R_1^{tst})^2 + (R_2^{tr} - R_2^{tst})^2 + (R_3^{tr} - R_3^{tst})^2}$$

*Varshavsky, Alexander & LaMarca, Anthony & Hightower, Jeffrey & de Lara, Eyal. (2007). The SkyLoc Floor Localization System. 125-134. 10.1109/PERCOM.2007.37.

Fully Connected Network



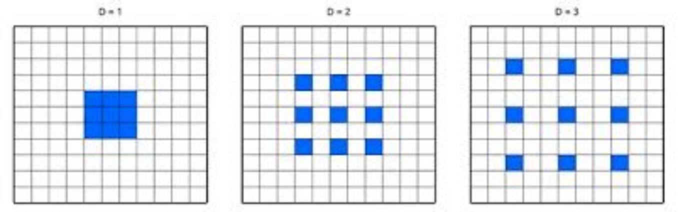
1D-conv CNN



1@ 150 x 42
10@ 141x 42
12@ 132x 42
84@ 66 x 42
91@ 59 x 42
96@ 54 x 42
123@ 27 x 42
@1728
@50
@ 6
Input
Conv
Conv
Max pool
Conv
Conv
Max pool
Flatten
Dense
Output

SeriesNet

- Uses dilated causal convolution



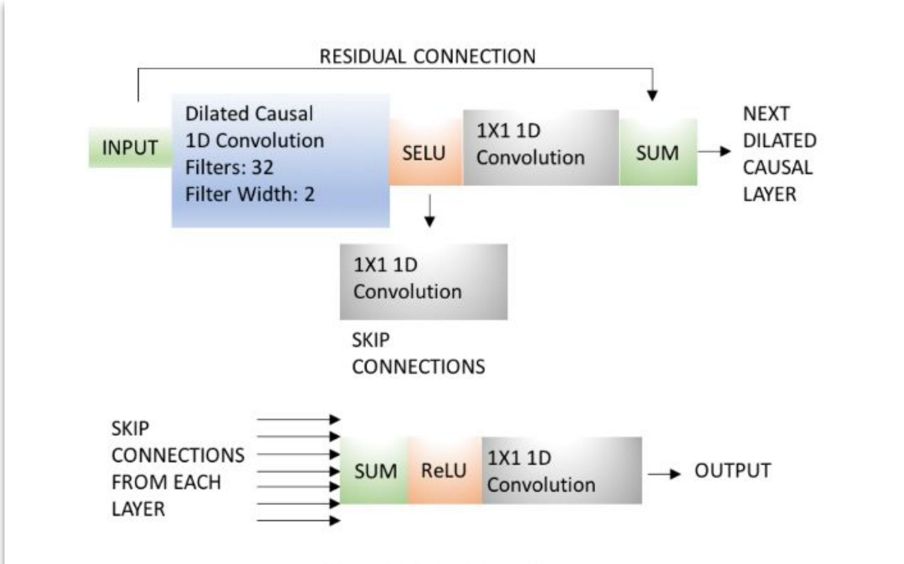
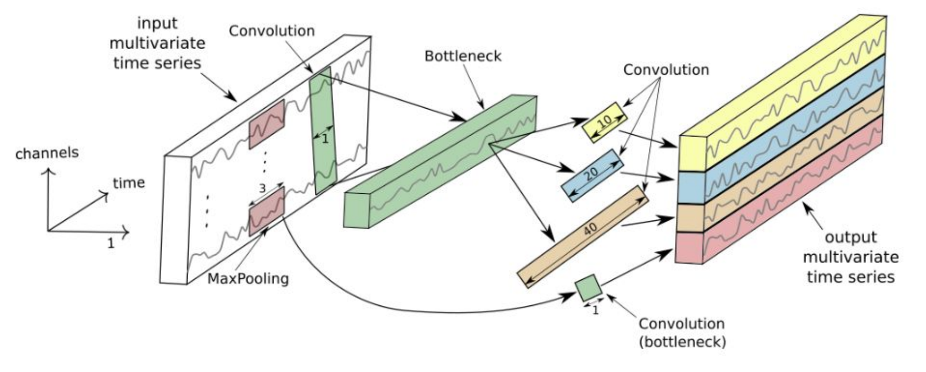
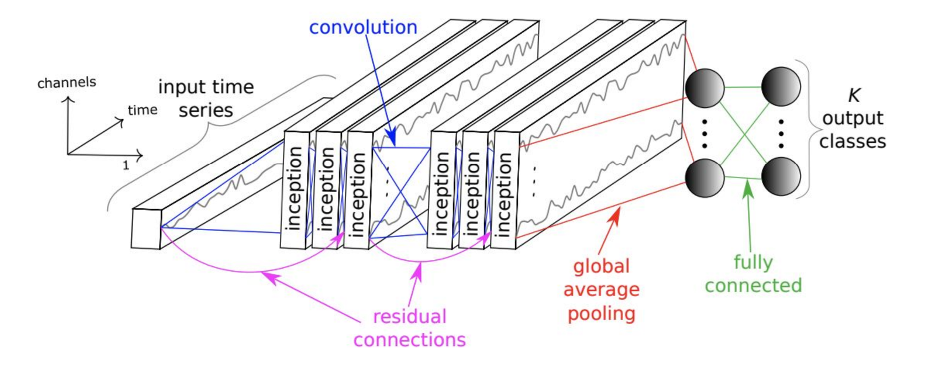


Figure 5: SeriesNet architecture

InceptionTime

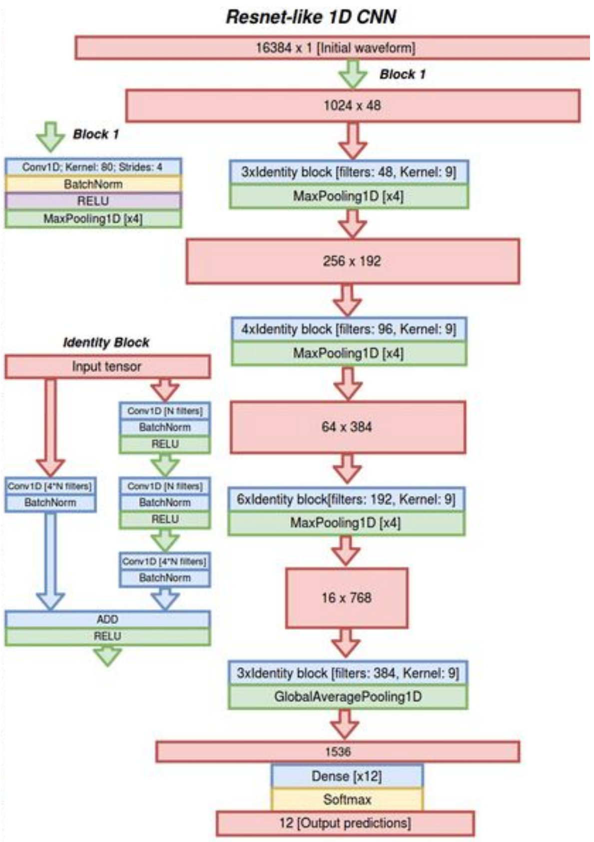
- Based on the Inception network
- Our final model uses 3 inception blocks





ResNet

- Follows the same architecture of the original ResNet but uses 1D convolutions



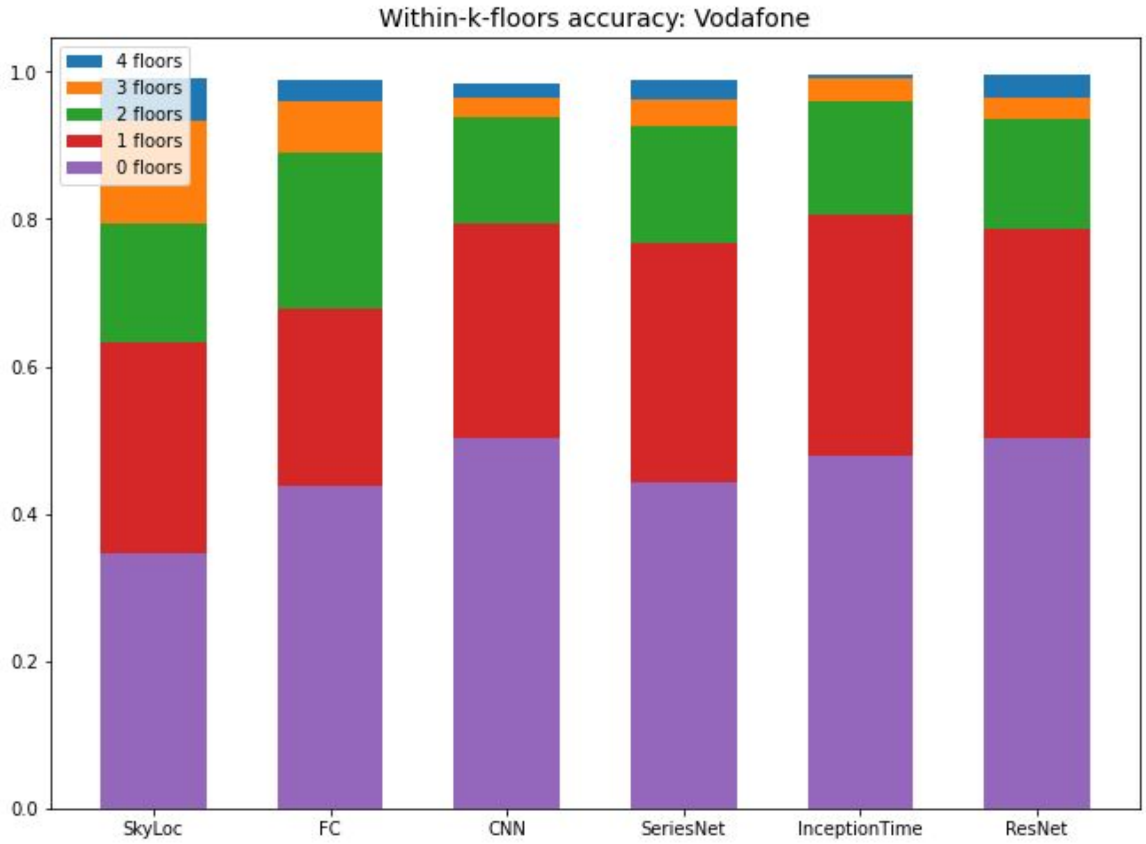
Results (Homogeneous Datasets)

Dataset	SkyLoc	FC
HTC X9	100	99.8
Moto G5	100	99.8
Oneplus 6	100	100
Combined Dataset	99.9	99.8

Results (Heterogeneous Datasets)

Maximum Accuracy at k floors

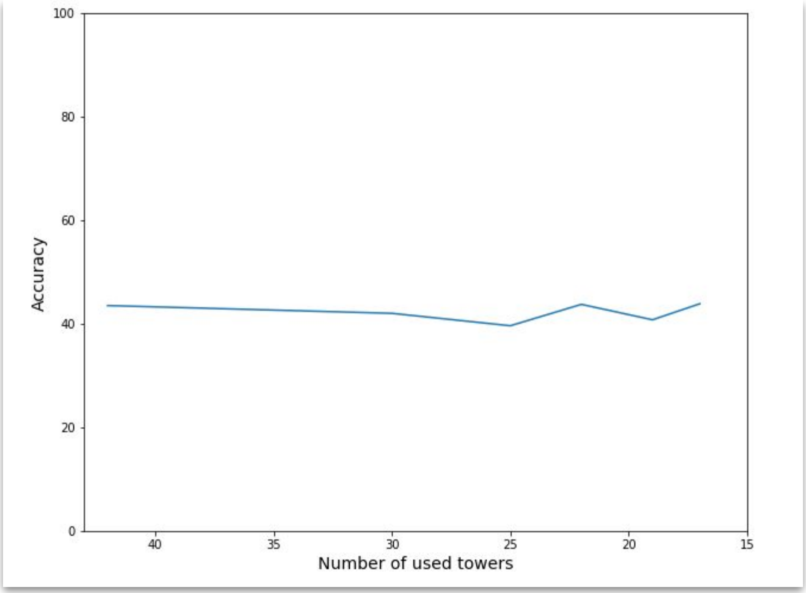
Within-k-floors	SkyLoc	FC	CNN	SeriesNet	InceptionTime	ResNet
0	34.6	43.8	50.2	44.4	47.8	50.2
1	63.3	67.8	79.3	76.7	80.7	78.6
2	79.4	88.9	93.8	92.7	96.1	93.5
3	93.2	95.9	96.4	96.2	99.2	96.5
4	99.1	99	98.3	98.9	99.7	99.5
5	100	100	100	100	100	100



Accuracy Plots for various architectures using a heterogeneous vodafone dataset

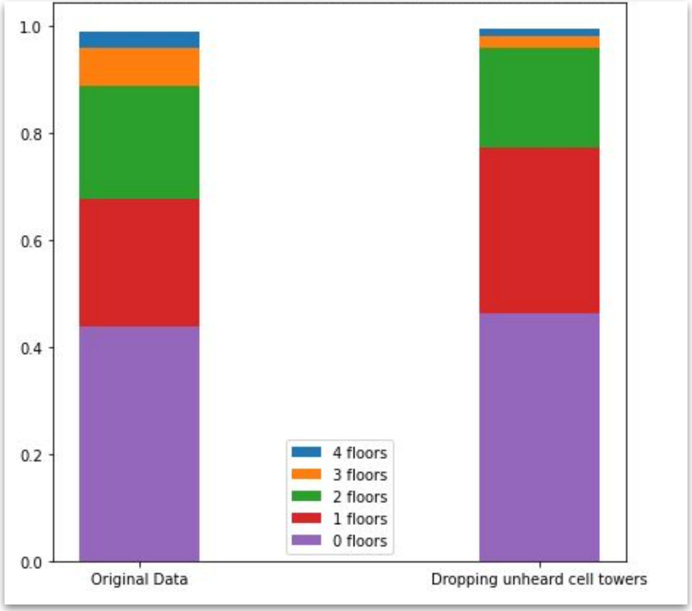
Feature Selection

- Method 1:
    - Drop cell towers with a fewest number of samples



Feature Selection

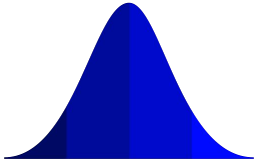
- Method 2:
  - Drop cell towers that were not heard by all phones in the dataset



Data Augmentation

- Generated new samples using the gaussian noise method from literature*
  - Involves sampling random gaussian noise and adding it to existing data to generate new examples
- This had no significant effect on accuracy

[21, 0, 14, 3, 0] +



→ [23, 1, 13, 6, 2]

Old Sample — Gaussian Noise — Generated Sample

* H. Rizk, A. Shokry and M. Youssef, "Effectiveness of Data Augmentation in Cellular-based Localization Using Deep Learning," 2019 IEEE Wireless Communications and Networking Conference (WCNC), Marrakesh, Morocco, 2019, pp. 1-6.

Demo

- Labelled RSS samples
  - Each row represents a sample and each column represents a cell tower id

	22171	22172	22175	22243	22706	22842	24611	36500	36775	4167	4241	4560	4595	49977	49978	49979	50030	50034	50035	FLOOR
0	0	0	5	0	0	0	0	4	0	0	5	0	0	0	19	8	0	10	0	0
1	0	0	0	0	0	0	0	0	0	9	15	0	0	12	27	12	0	22	0	4
2	0	0	0	0	0	0	13	0	0	0	11	0	0	11	20	17	0	20	13	1
3	0	0	0	0	0	0	0	0	0	0	0	0	0	11	20	16	8	20	0	1
4	0	0	0	0	0	0	0	0	0	11	0	0	0	0	21	0	0	21	0	3
5	0	0	0	0	0	0	0	13	8	0	13	0	0	0	21	13	0	17	0	3

Demo

```
[91] normalized_samples_x = samples_x/31

     predicted_floors = model.predict_classes(normalized_samples_x)
     true_floors = sample_floors[:, 0]
     error = np.abs(predicted_floors - true_floors)
```

```
True floors:  [0 4 1 1 3 3]
Pred. floors: [0 5 1 1 3 1]

Error:        [0 1 0 0 0 2]
```

Team Members Contribution

- Khaled
  - Preprocessing and dataset generation
  - FC model construction
  - Feature Selection and Data Augmentation
  - Experimenting with Inception model
- Aya
  - Generating sequence datasets
  - Time series CNN model construction
  - Experimenting with SeriesNet model
  - Experimenting with 1D ResNet model

Conclusions

- Alot of variations affect cellular data received by phones. Main variation factors we encountered:
    - Device/Hardware
    - Signal power variation overtime
    - Cell tower dropping

- Our tests for homogeneous data are inaccurate
    - We recently conducted another round of data collection
    - We seperated the collection of training and test data and accuracy dropped to 30% on homogeneous data

Next Steps

- Experiment more with our newly collected data
  - Collected more data from the Electrical Engineering building and the Administration building
- Apply other data augmentation techniques
  - We think the tower dropping method can improve our model’s performance

Acknowledgement

We'd like to express our deep and sincere gratitude and to Prof. Moustafa Youssef and Eng. Hamada Rizk for their mentoring and the constant support and encouragement they showed us.

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