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Efficient Smartphone Position Detection Using Neural Networks

Mobile Sensing Systems Lab

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SS15

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Introduction

- ➔ Context Awareness
- ➔ Challenges
  - ◆ Difficulties in Training
  - ◆ Variety of User Behaviors
  - ◆ Multiple Devices

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Implementation

- ➔ Sample Collection
- ➔ Training
- ➔ Prediction

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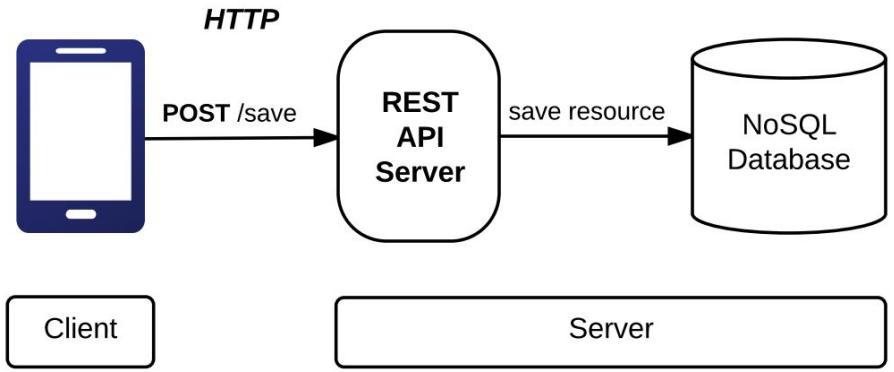
Sample Collection

- NoSQL Database on AWS EC2
- RESTful Server in Node.js



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Sample Collection

- ➔ Sampling Rate of 500ms.
- ➔ Position Labels: “InHand”, “SidePocket”, “Idle”, “Handbag”.
- ➔ Experimental Noise


```
{"t":1440867810092,"v0":1013.56,"n":"pressure","p":"InHand","e":0},

{"t":1440867810113,"v0":-0.17266846,"v1":-0.0725708,"v2":9.80484
,"n":"gravity","p":"InHand","e":0},

{"t":1440867810114,"v0":0.064941406,"v1":0.09411621,"v2":-0.1418457,n"
:"linacc","p":"InHand","e":0},

...
```

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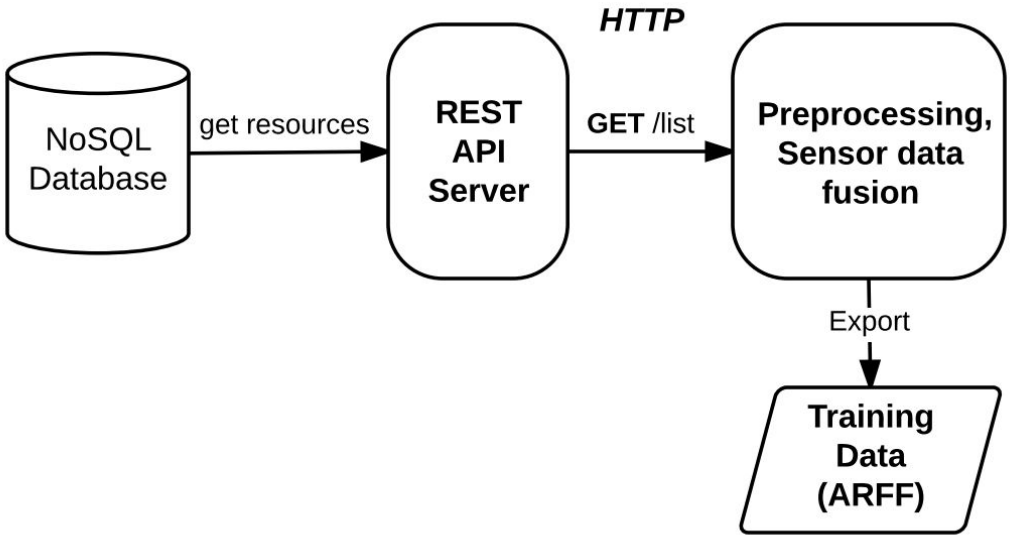
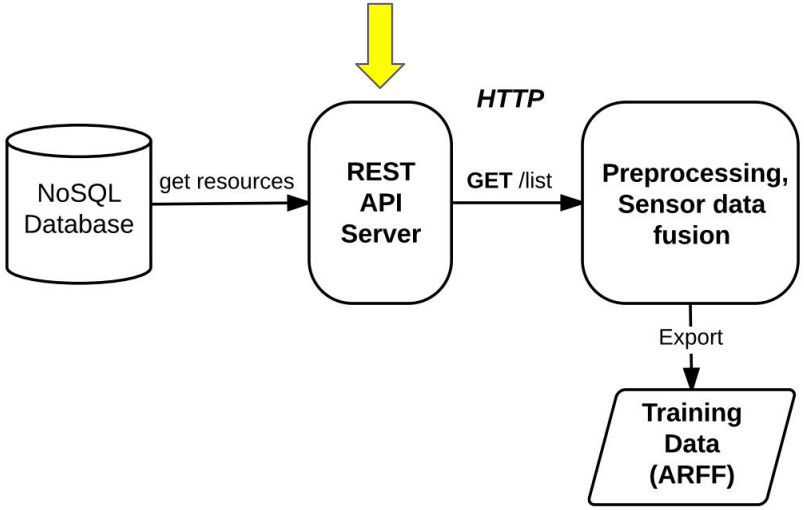
Training

- ➔ Query
- ➔ Sensor Fusion
- ➔ Exporting
- ➔ Training Model



Training: Query

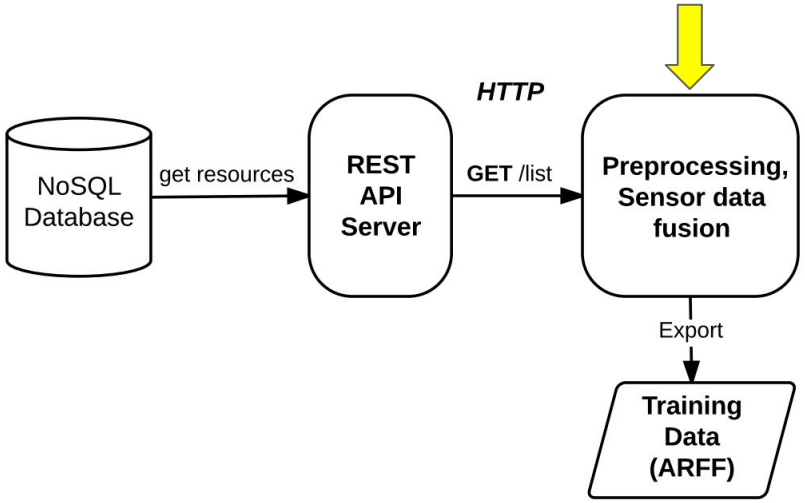
- RESTful API
- Query on Specific Timeframe
- JSON Format



Training: Sensor Fusion

```
Raw sample data (revisited):
{"t":1440867810092,"v0":1013.56,"n":"pressure","p":"InHand","e":0},
{"t":1440867810113,"v0":-0.17266846,"v1":-0.0725708,"v2":9.80484 ,"n":"gravity","p":"InHand","e":0},
{"t":1440867810114,"v0":0.064941406,"v1":0.09411621,"v2":-0.1418457,n":"linacc","p":"InHand","e":0},
{"t":1440796909166,"v0":-0.11802673,"v1":0.48486328,"v2":-0.20988464,"n":"rotation","p":"SidePocket","e":0},
{"t":1440796909202,"v0":19,"n":"light","p":"SidePocket","e":0},
...
```

- ➔ Remove experimental noise
- ➔ Fuse sensor data
- ➔ Add mathematical features



Sample Pool:

496654 raw sensor readings

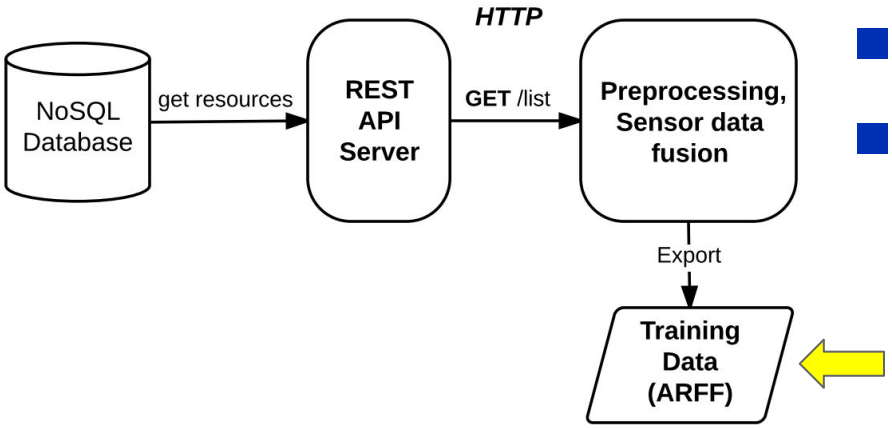
29464 training instances

Training: Conversion and Exporting

```
@relation 1441901290_complex_features

@attribute linaccX numeric
@attribute linaccY numeric
@attribute linaccZ numeric
@attribute linaccMag numeric
@attribute rotationX numeric
@attribute rotationY numeric
@attribute rotationZ numeric
@attribute pressure numeric
@attribute light numeric
@attribute proximity numeric
@attribute gravityX numeric
@attribute gravityY numeric
@attribute gravityZ numeric
@attribute position {SidePocket,Idle,InHand,Handbag}

@data
0.0261 0.0170 0.0154 0.0294 0.4287 0.8387 -0.1052 1010.6511 11.6 0 -4.1589 -0.1735 -8.8652 SidePocket
0.0228 0.0761 0.0212 0.1441 0.4263 0.8775 -0.1043 1010.6517 11.6 0 -4.1935 -0.1815 -8.8630 SidePocket
...
```



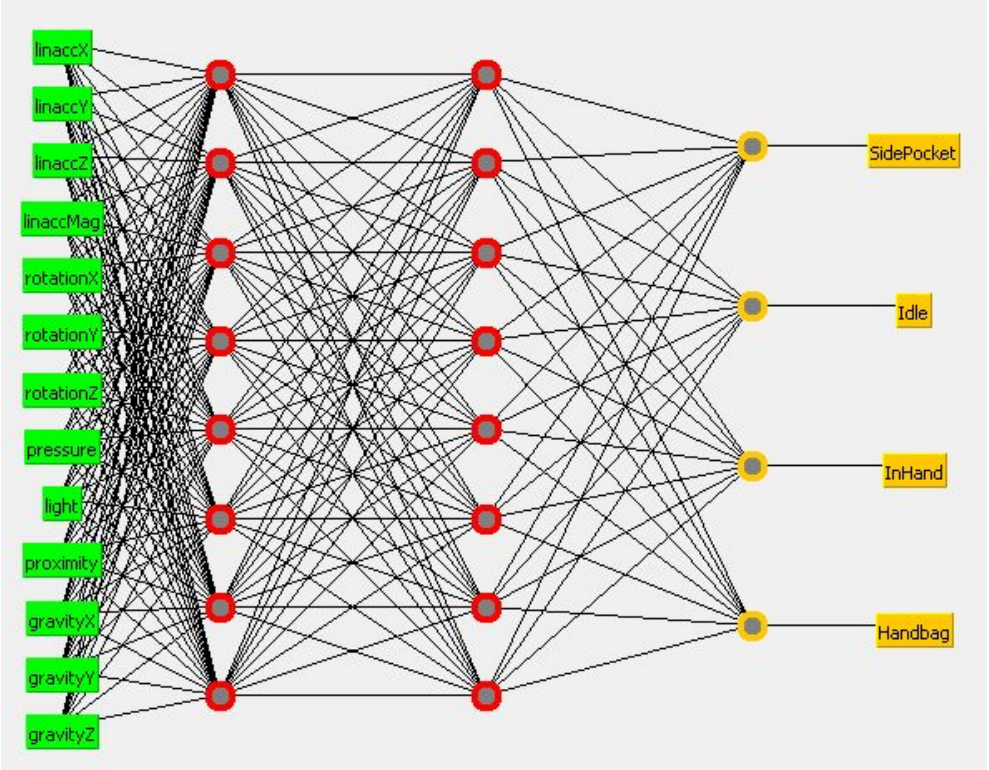
*** For the sake of this presentation, all values are truncated to four floating digits**

Training: Model

Multilayer Perceptron
Nodes: 13 - 8 - 8 - 4

29464 instances
SidePocket: 5350
Idle: 11348
InHand: 7270
Handbag: 5496

Learning rate: 0.3
Iterations: 500



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Training: Model

10-folds cross validation

99.8% accuracy over training data

	SidePocket	Idle	InHand	Handbag
SidePocket	5326	0	2	22
Idle	1	11347	0	0
InHand	0	0	7270	0
Handbag	13	0	0	5483

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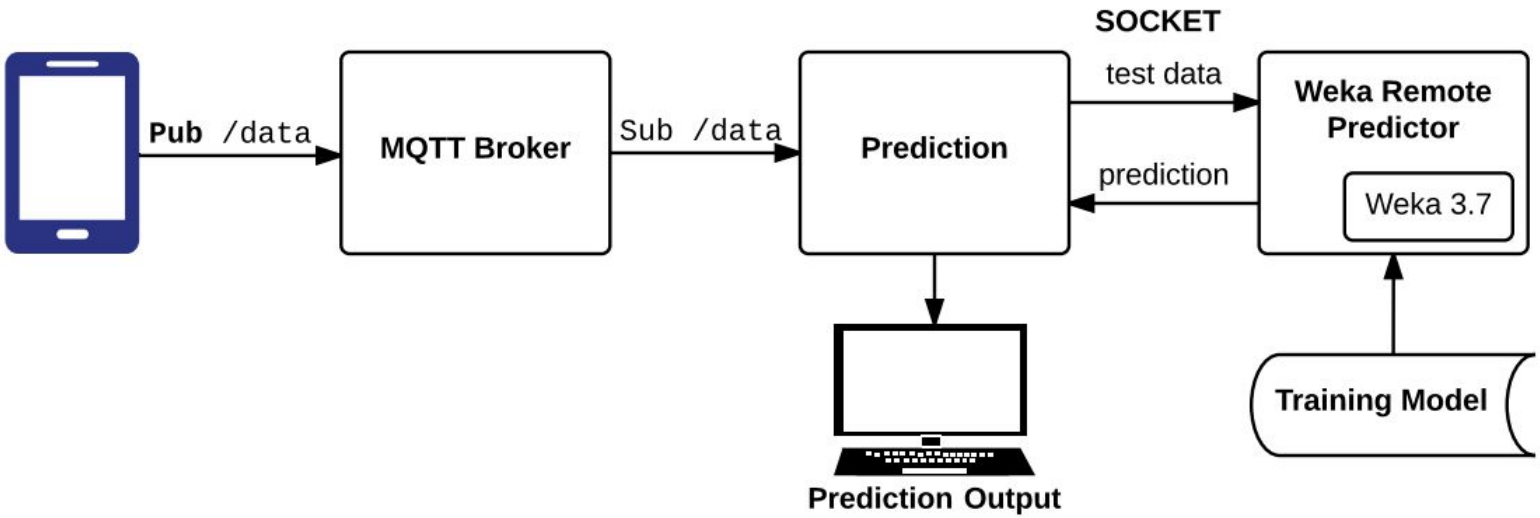
Prediction

- ➔ Real-time sensor data transmission
- ➔ Pre-processing
  - ◆ Sensor data fusion
  - ◆ Mathematical features
- ➔ Classification



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Evaluation

24774 raw sensor readings

1266 training instances

	SidePocket	Idle	InHand	Handbag
SidePocket	267	1	0	38
Idle	0	288	0	0
InHand	1	21	238	2
Handbag	10	53	0	347

	SidePocket	Idle	InHand	Handbag
Precision	96%	79%	100%	90%
Recall	87%	100%	91%	85%
Accuracy	86%	79%	92%	80%

Average

91% precision

91% recall

84% accuracy

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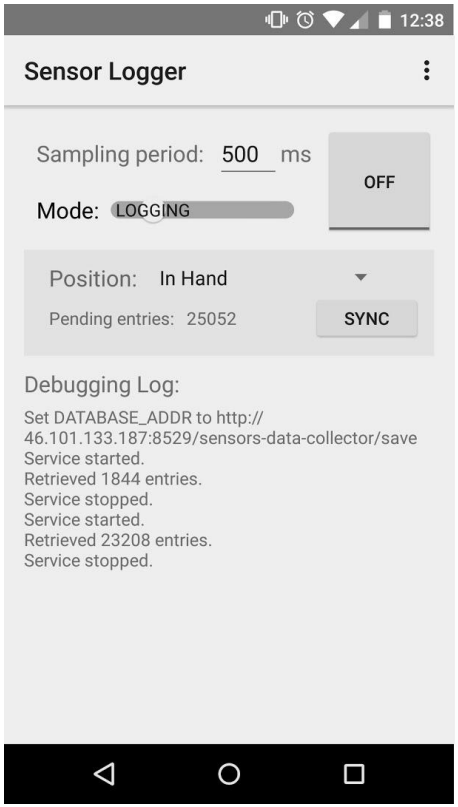
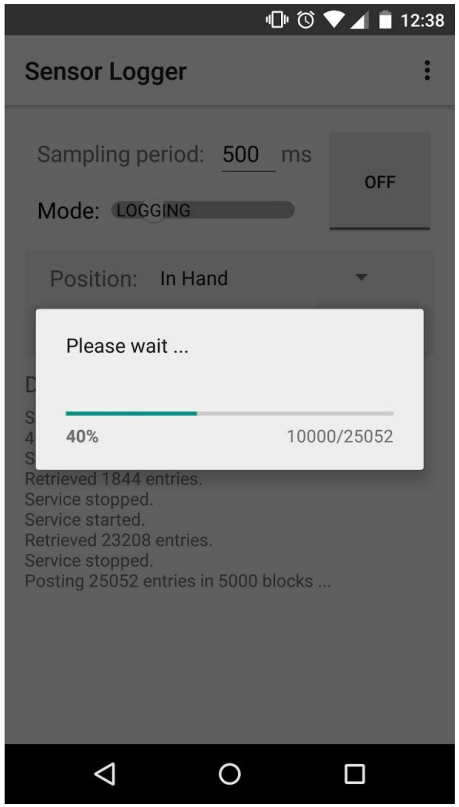
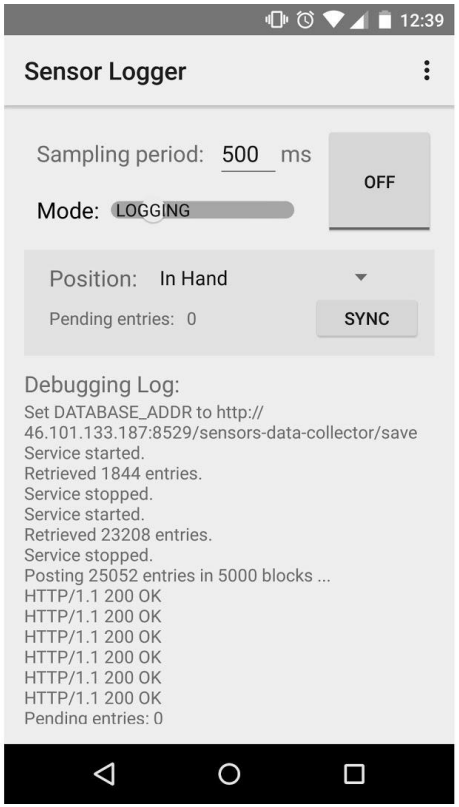
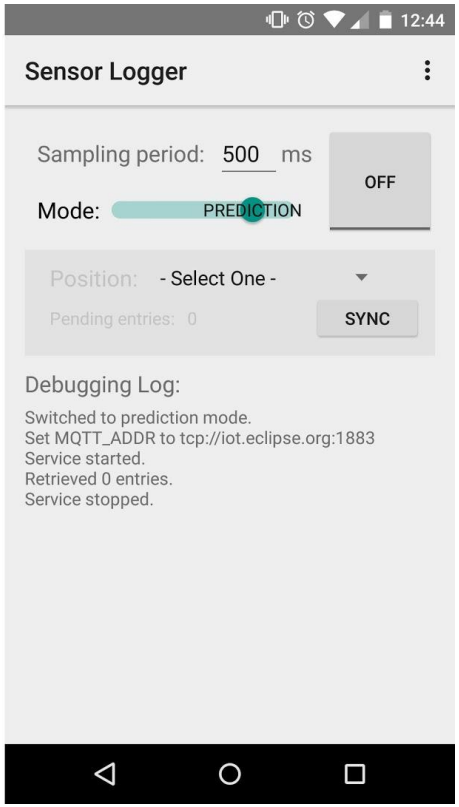
Demo









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Q & A