



INSTITUTO  
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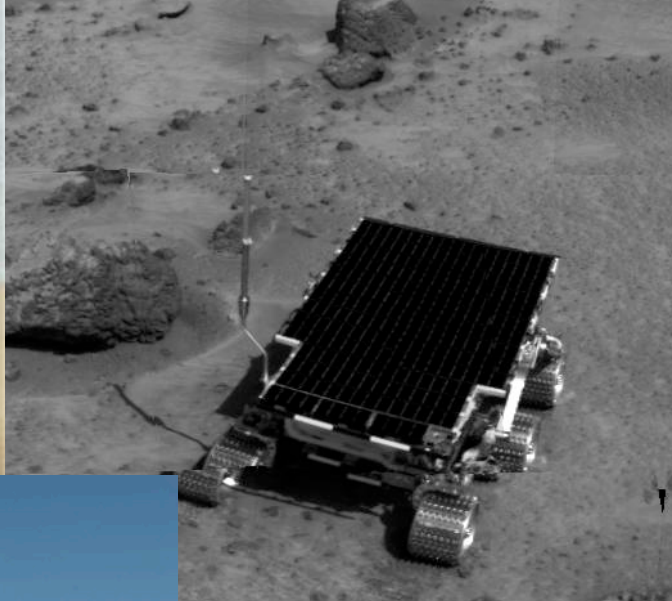
# An Analysis of Navigation Algorithms for Smartphones using J2ME

Mobilware 2009

# Outline

## Roadmap

- Introduction
- Concepts
- Approach
- Experiments & Results
- Conclusions



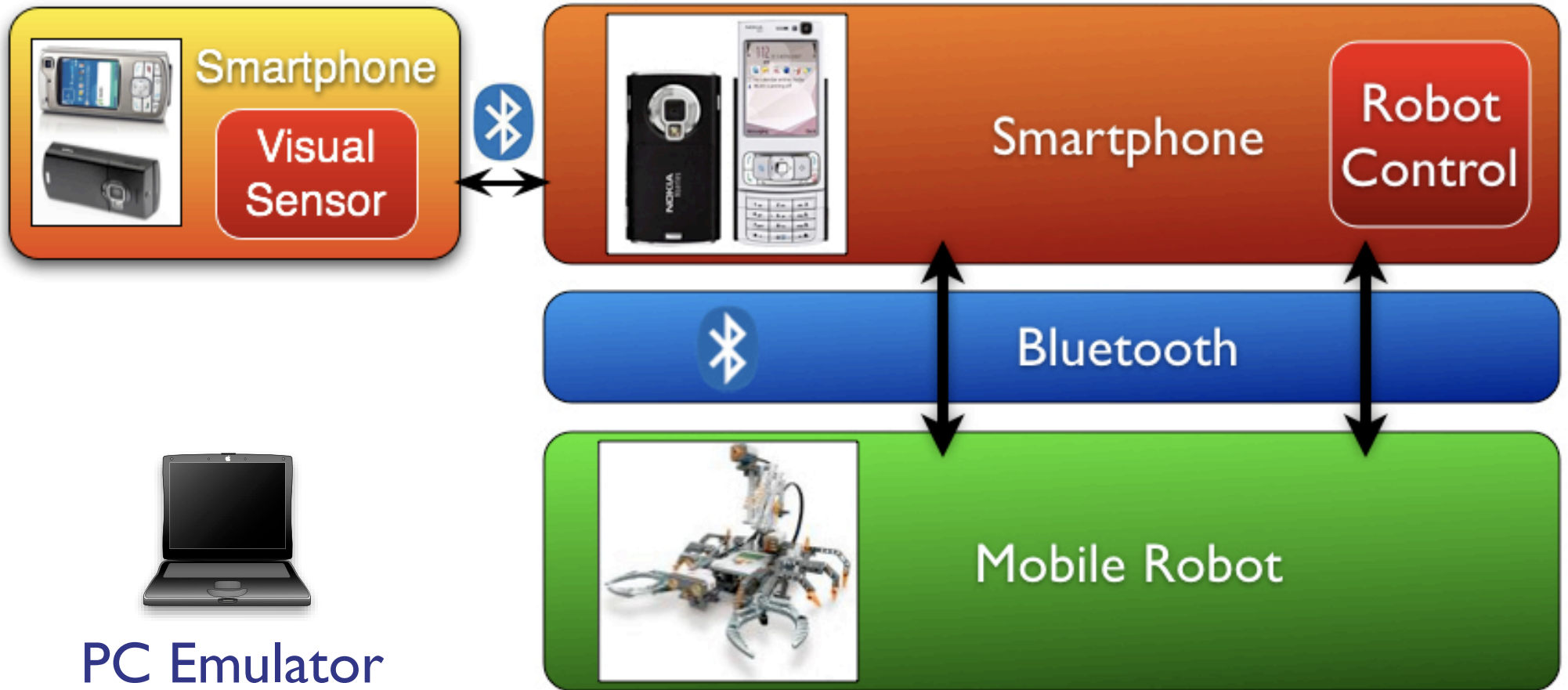
# Objectives & Contribution

The main objectives and contributions

- Research and develop navigation algorithms for embedded systems (*J2ME*)
- Analyze smartphone feasibility, capacity and performance (*control unit and visual sensor*)
- Test on physical prototype (*mobile robot + smartphones*)

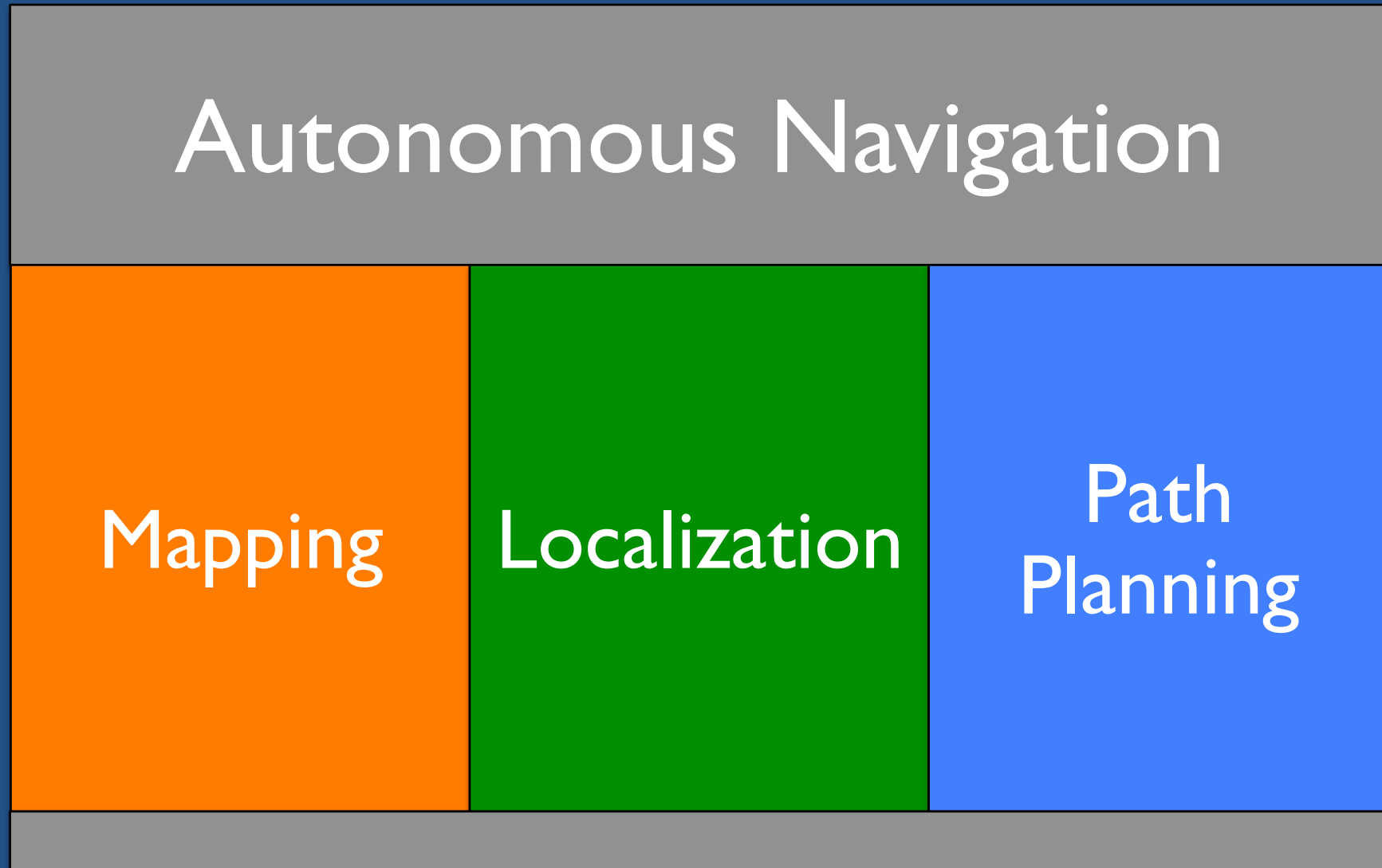
# System Architecture

## Main Components



# Autonomous Navigation

Navigation problems





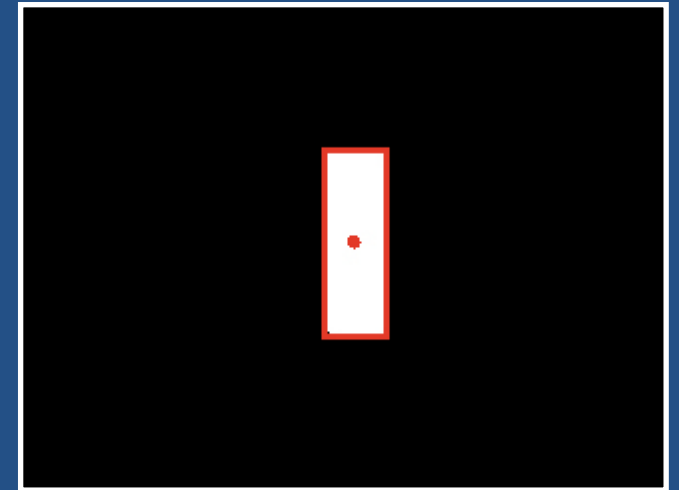
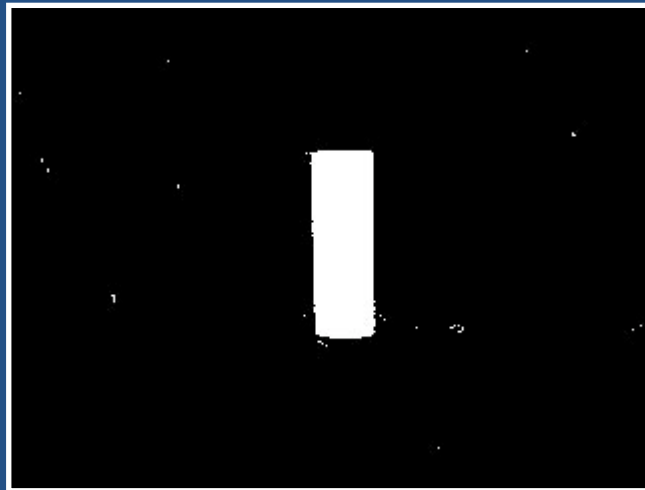
# Approach

Implementation

# Visual Landmark Recognition

## Mapping

Recognition of artificial landmarks, placed previously in the environment.



Average distance error: 5% - 6%

Average orientation error: 10% - 11%



# Visual Landmark Recognition

## Evaluation

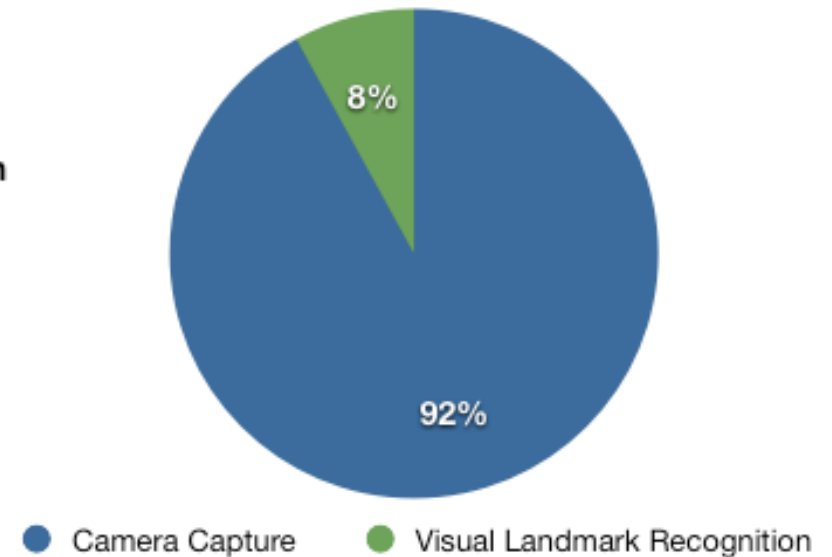
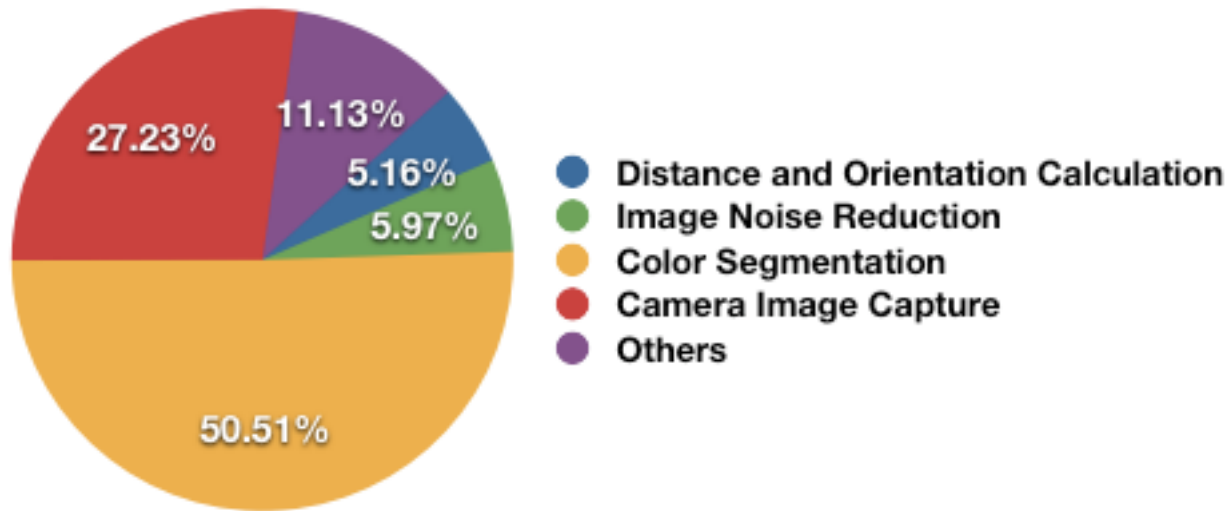


Image Size:  
320x240

Representation:  
RGB array

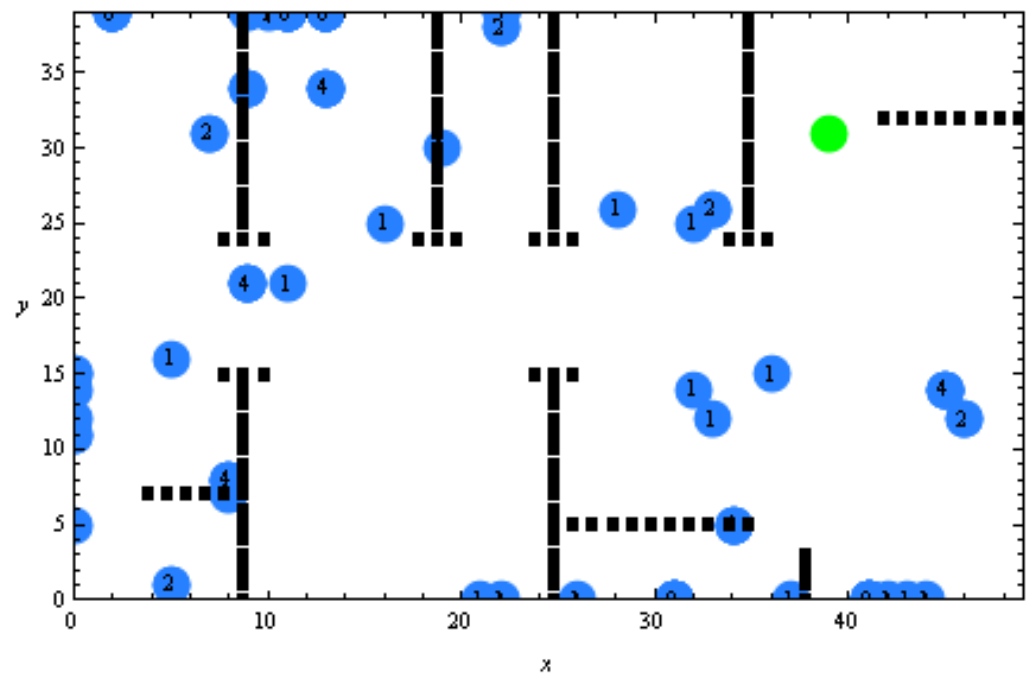
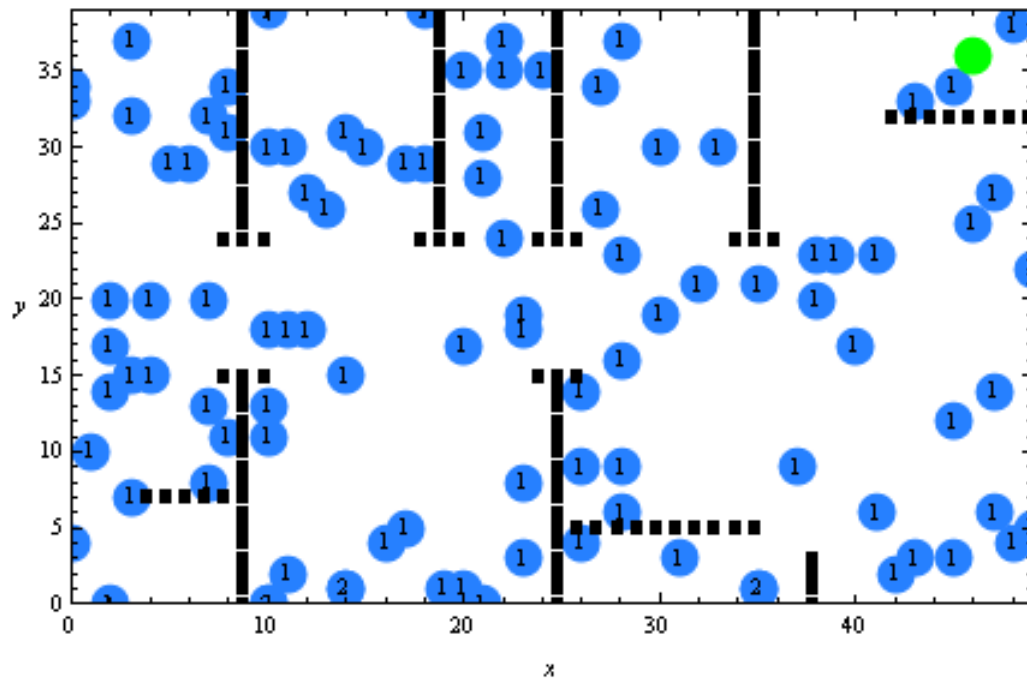
| PC Emulator | Nokia N80 | Nokia N95 |
|-------------|-----------|-----------|
| ~453 ms     | ~3000 ms  | ~5800 ms  |

~2x

# Particle Filter

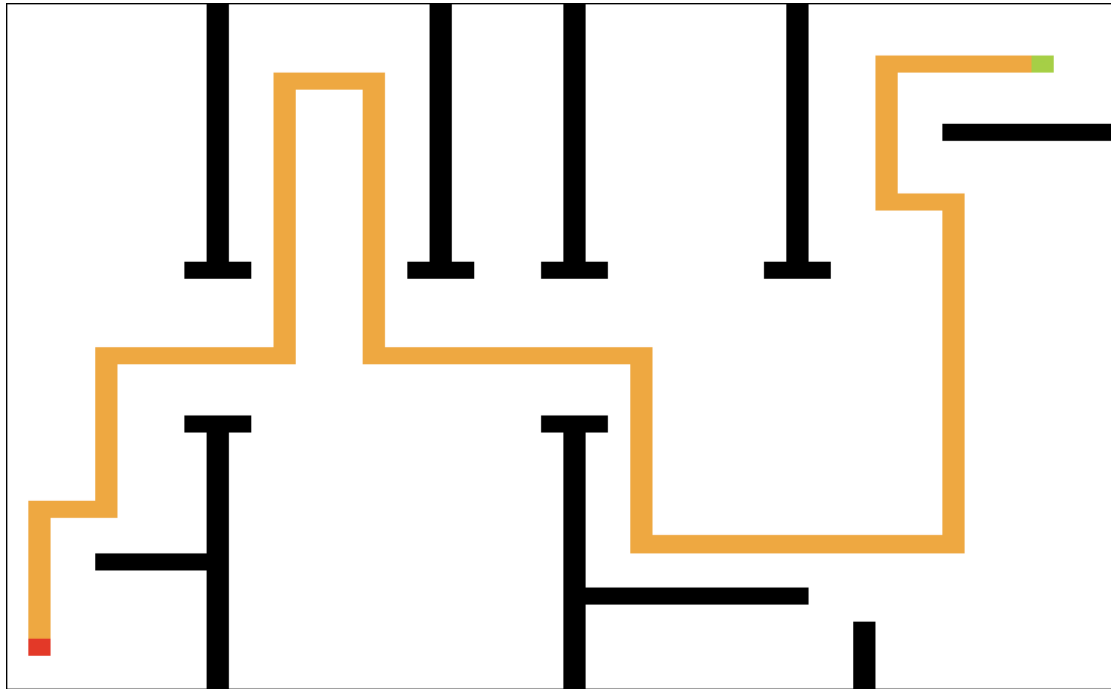
## Localization

Samples that show the belief of the robot's position.

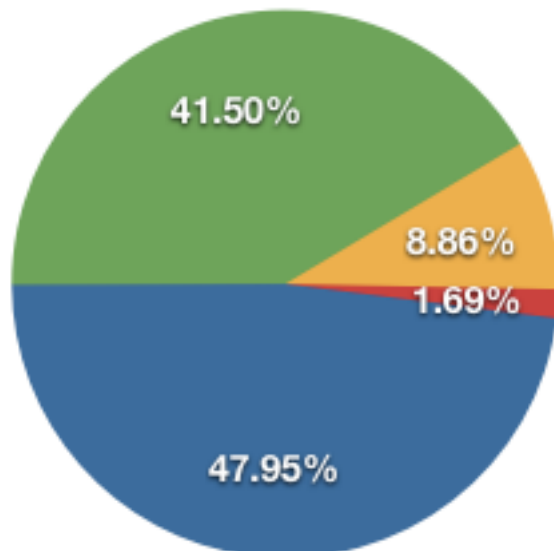


# Particle Filter

## Evaluation



Representation:  
Matrix



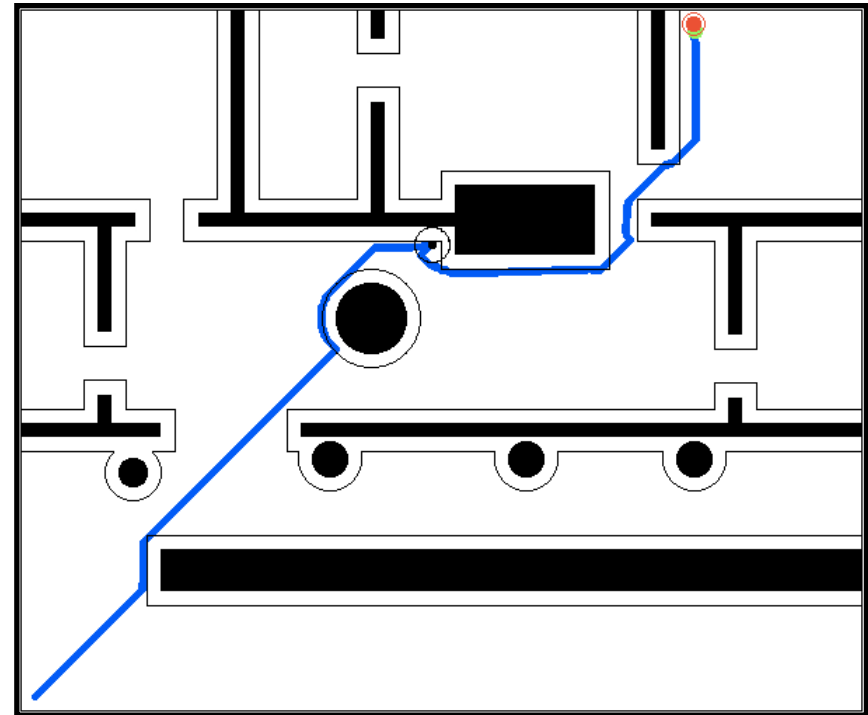
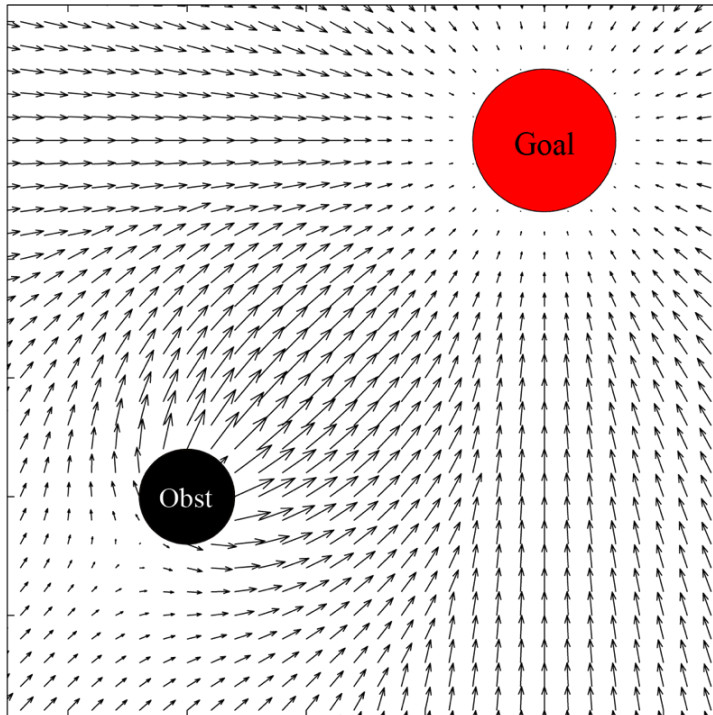
- Prediction Phase
- Update Phase
- Resample Phase
- Others

$\sim \frac{1}{2} \times$

|                    |          |
|--------------------|----------|
| <b>PC Emulator</b> | ~78 ms   |
| <b>Nokia N80</b>   | ~3600 ms |
| <b>Nokia N95</b>   | ~1700 ms |

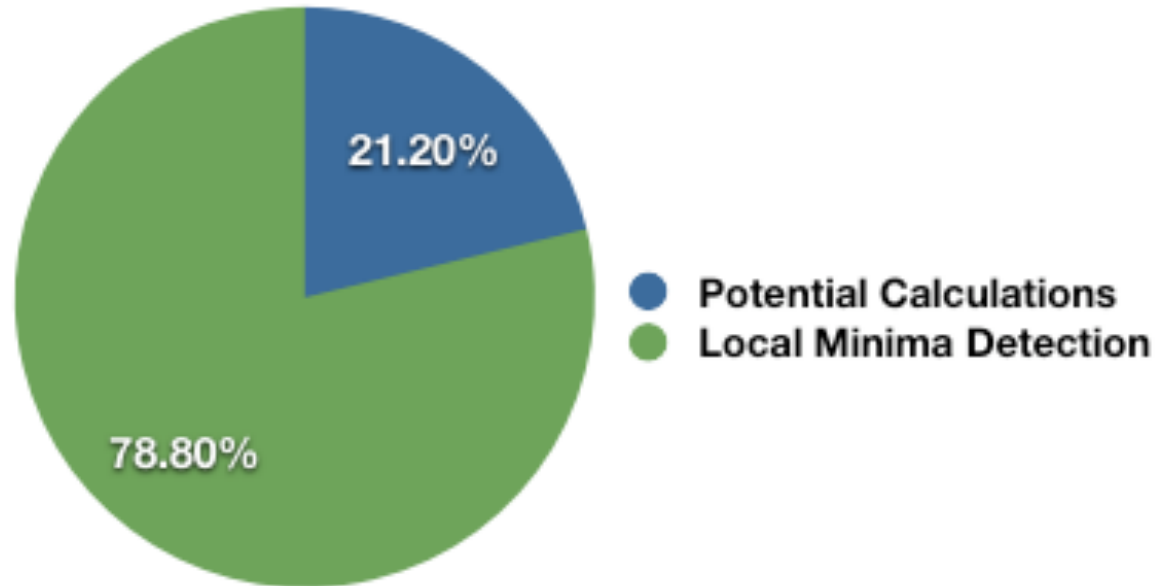
# Potential Fields

## Path Planning/Obstacle Avoidance



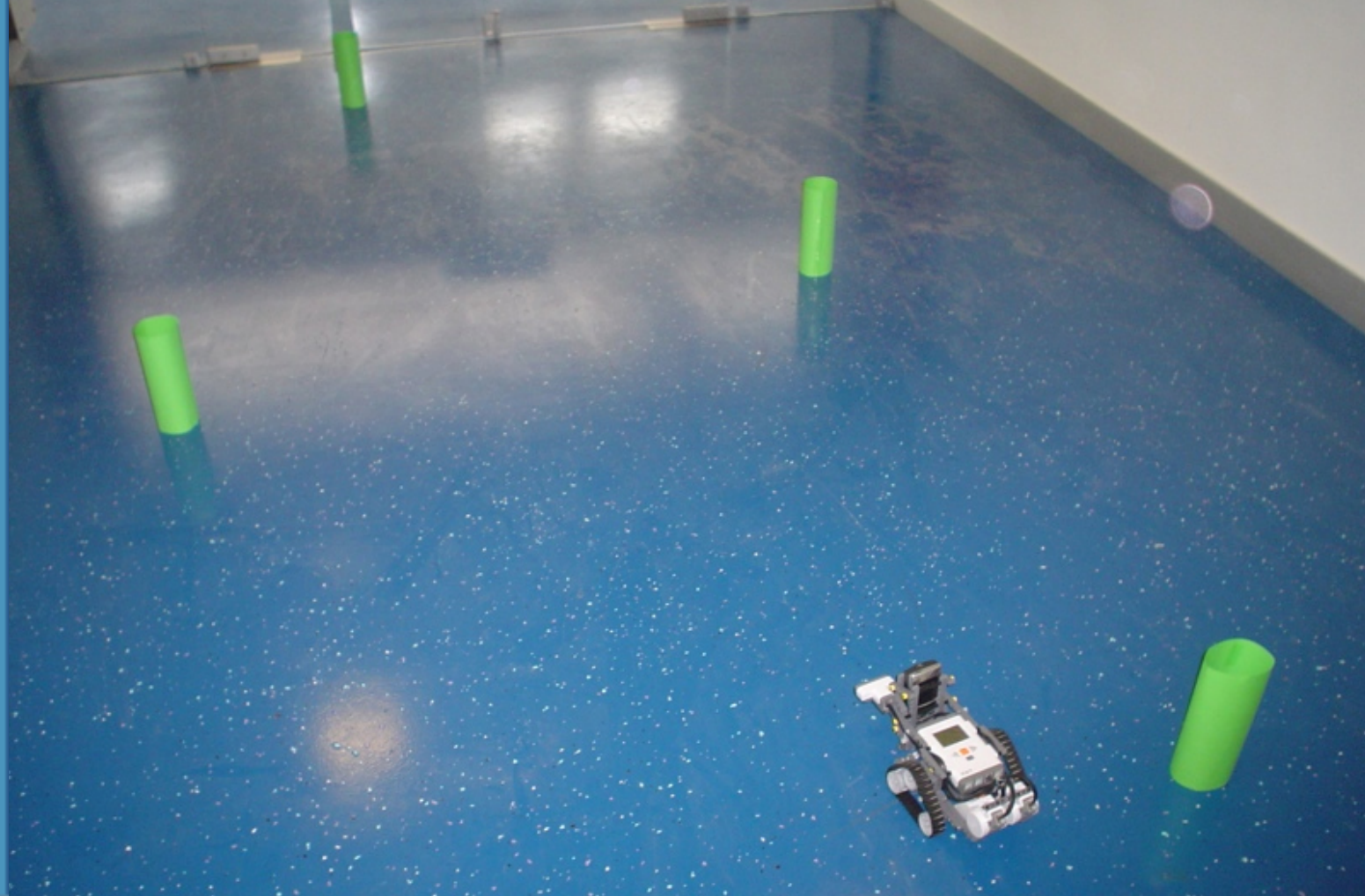
# Potential Fields

## Evaluation



Representation:  
Object Vectors

|             | Average Step Time |
|-------------|-------------------|
| PC Emulator | ~11 ms            |
| Nokia N80   | ~377 ms           |
| Nokia N95   | ~278 ms           |

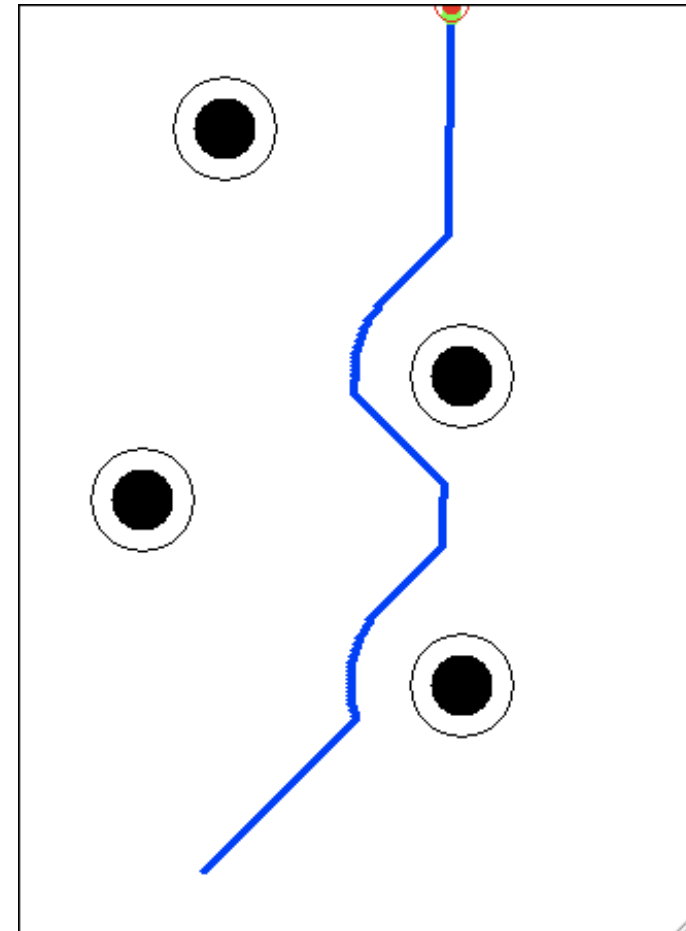
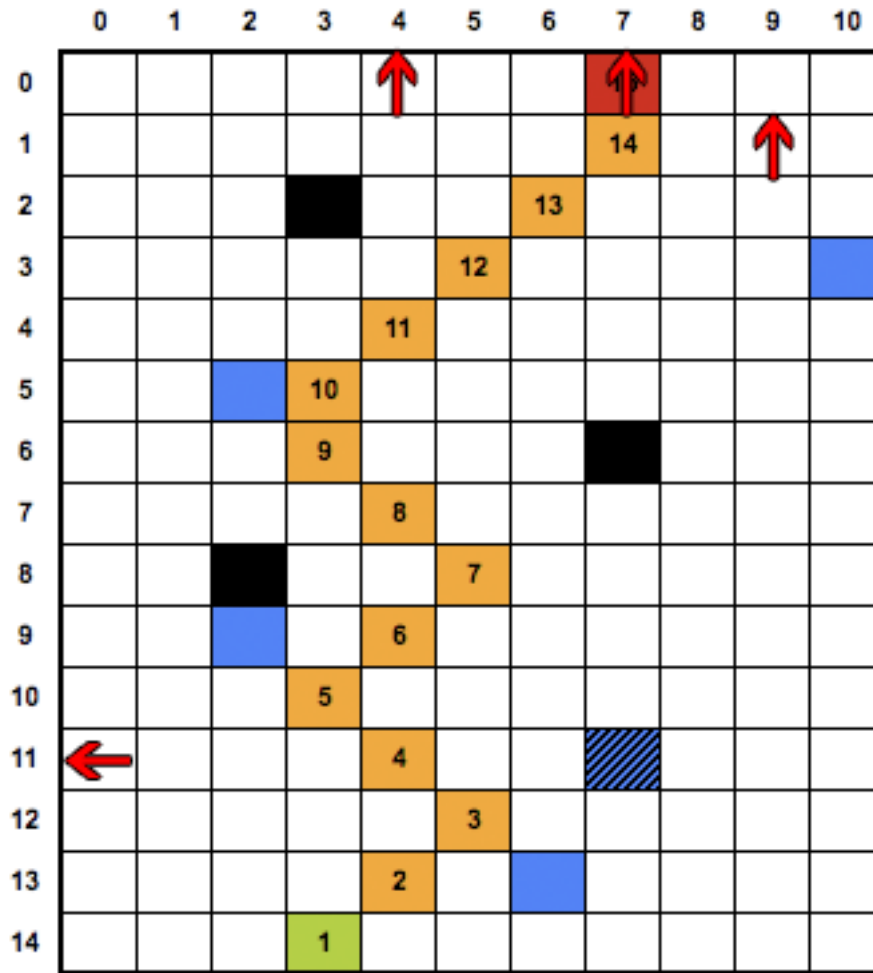


# Field Experiment

Results

# Experiments on the field

## Mapping, Localization and Path Planning



# Conclusions

- Although hardware and software restrictions, navigation using smartphones is possible:
  - The system can identify landmarks, retrieve possible present locations and plan its motion avoiding obstacles.
- Current overall capacity of high-end smartphone models and J2ME capabilities.
- Smartphones are ready for more computationally demanding tasks. **Possibilities are endless!**



Thank you, questions?

April 2009