Athens University of Economics and Business
Master of Science in Computer Science

The mobile phone as a platform for assisting the independent living of aging people

M.Sc. Thesis
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In this thesis

- We exploit the capabilities of mobile phones/PDAs in the context of a Smart Home environment to monitor the activities and assist aging people

- We propose:
  - An indoor positioning system
  - An application that helps people with limited vision

Motivation

Demographic trend

- Rapid growth of the elderly population and increase in life expectancy

New models of positive ageing

- Older adults are being empowered to lead fulfilling lives and adapt to degenerative changes to maintain functionality, autonomy and quality of life

Technology's promise

- Improve the well-being of the elderly, enabling them to lead their lives to a larger extent independently from healthcare institutions and their caretakers

Smart Home

Definition: The integration of technology and services through home networking for a better quality of living

A smart home for aging people can (should):

- Provide an environment that is constantly monitored to ensure the householder is safe and secure
- Automate specific tasks that a householder is unable to perform
- Alert helpers or carers if the householder is in difficulties
- Enable and empower the user

Positioning and trajectories recording in a Smart Home environment

- Safe environment
- Automated tasks

→

Patterns in daily behavior

→

Monitoring

- Need for: Indoor positioning
- Low cost: Using the mobile phone

Indoor positioning
Technologies and techniques

Using:

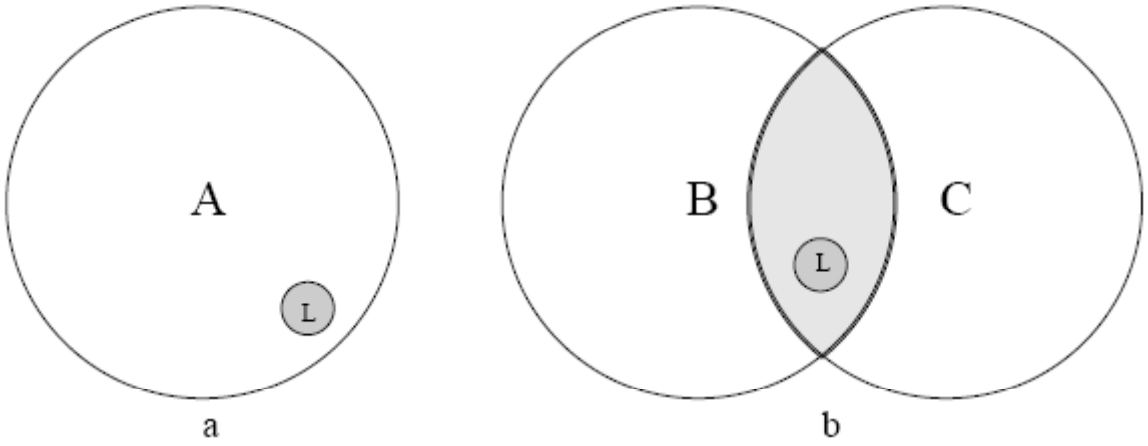
- Bluetooth
- Wi-Fi
- RFID
- Camera on mobile phone

How:

- Cell-based methods (simple discovery)
- Range-combining techniques
- Scene analysis – Fingerprinting

Cell-based methods

- Naive scanning and simple discovery
- Localization based on the visibility of beacons (and non-visibility), without using any distance or angle measurements
- Take advantage of the knowledge of the limited range of each of the beacons, using the region of intersection of the ranges of all visible beacons



Range-combining techniques

- Use signal characteristics information and perform calculations (usually time for a signal to propagate or angles) to determine the location of an entity in relation to some other infrastructure devices

Examples

- Time of Arrival
- Multilateration
- Triangulation - Angle of Arrival

Scene analysis - Fingerprinting

Fingerprints

- Collections of signal property readings

  (Link Quality, Received Signal Strength Indicator, Transmit Power Level, Response Rate, Signal-to-Noise ratio)

- Collections of images

Stages

- **Training stage**: Create database of fingerprints for each interesting location
- **Matching stage**: Compare the stored fingerprints with the current fingerprint of the device we want to locate and find best match using a matching algorithm

A fingerprint-based localization system that uses images captured by the mobile phone

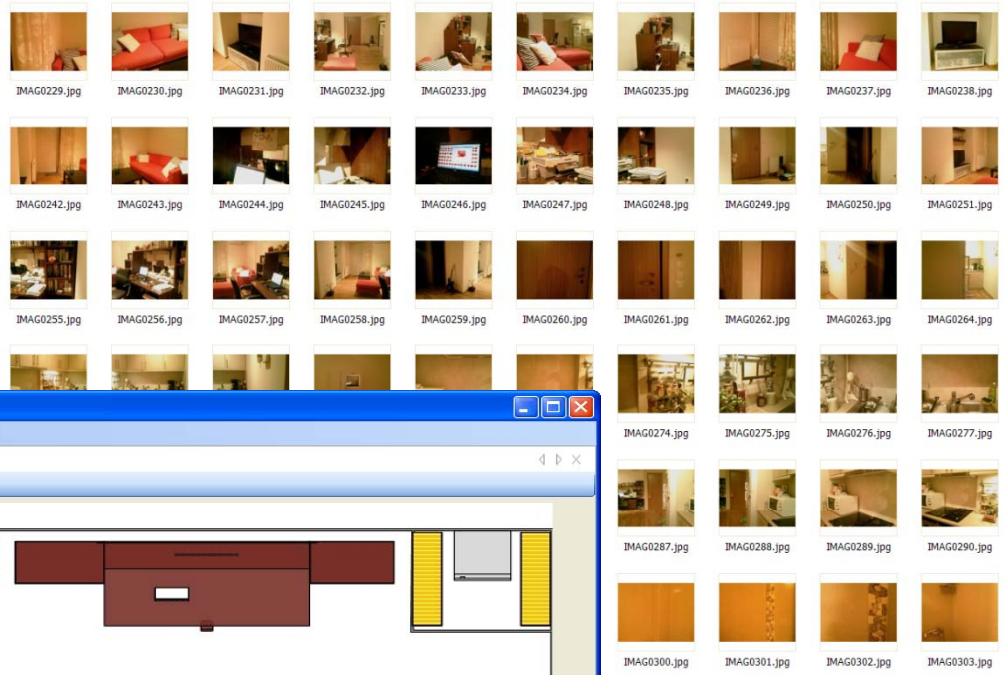
Indoor localization using mobile phone camera

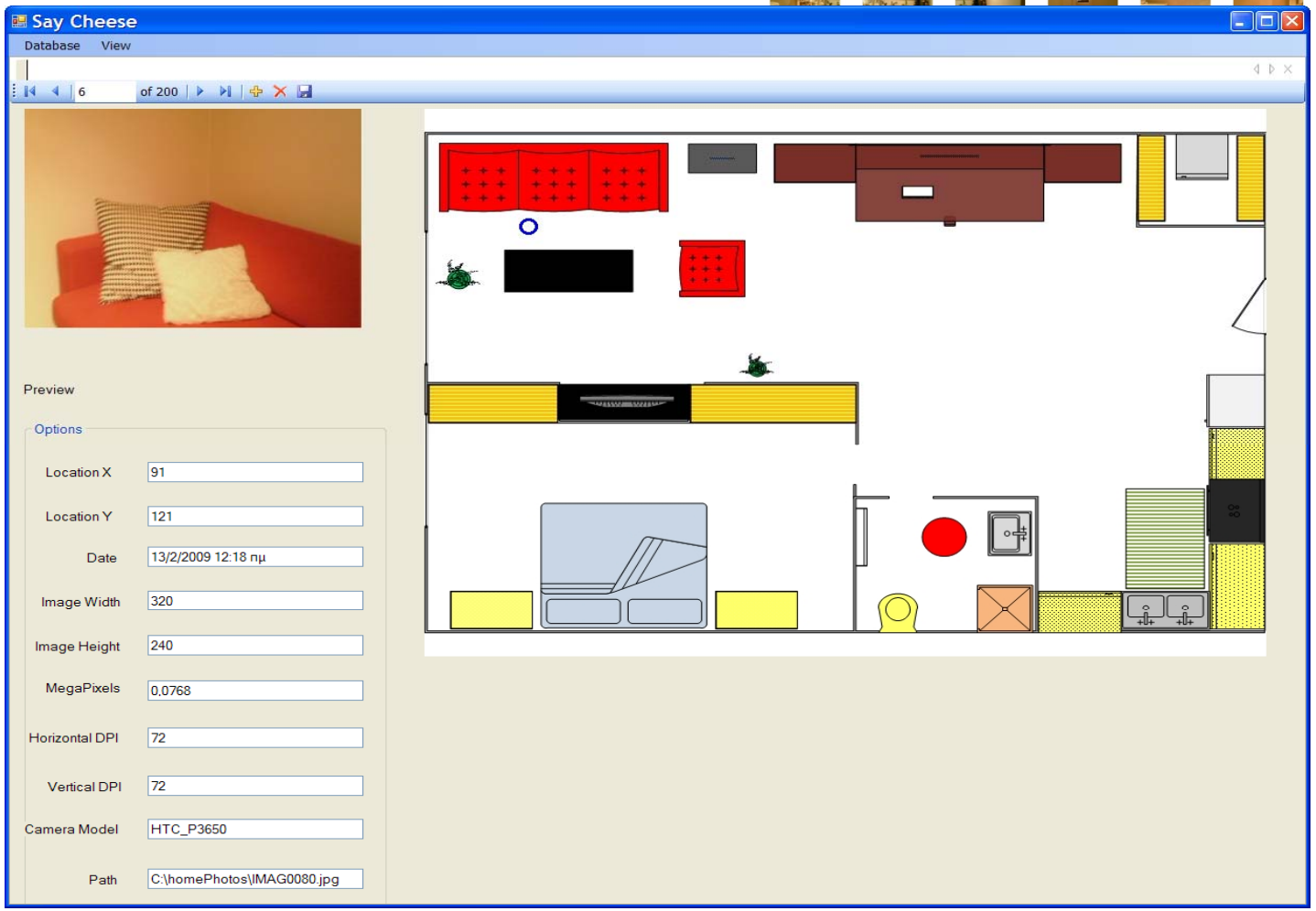
- Determine a user's location based on the camera images received from the PDA
- The PDA is worn by the user as a pendant and images are periodically captured and transmitted to a Web server
- The Web server returns the location of the user by comparing the received images with images stored in a database using off-the-shelf matching algorithms

Steps

- Create database with images and tag them manually
- Take a query image and send it to the server
- Compare it with the images stored in the database, using algorithms for image comparison
- Each algorithm assigns a weight to every image in the database which reflects the degree of similarity
- If the weight of the best match is less than a certain threshold, discard the query image
- Else, return the location of the image that matches the query image with maximum weight

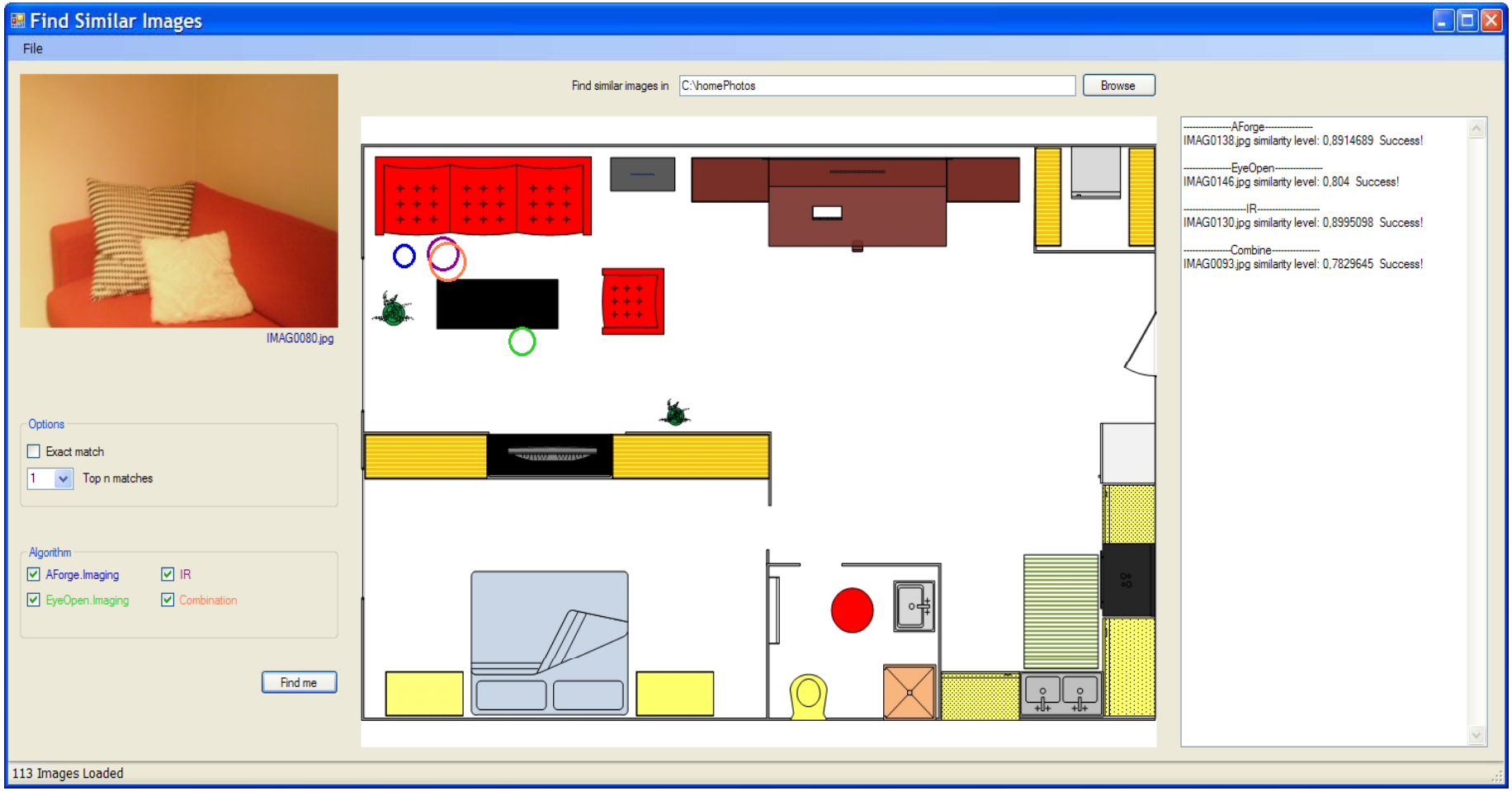
Training Stage





Matching Stage

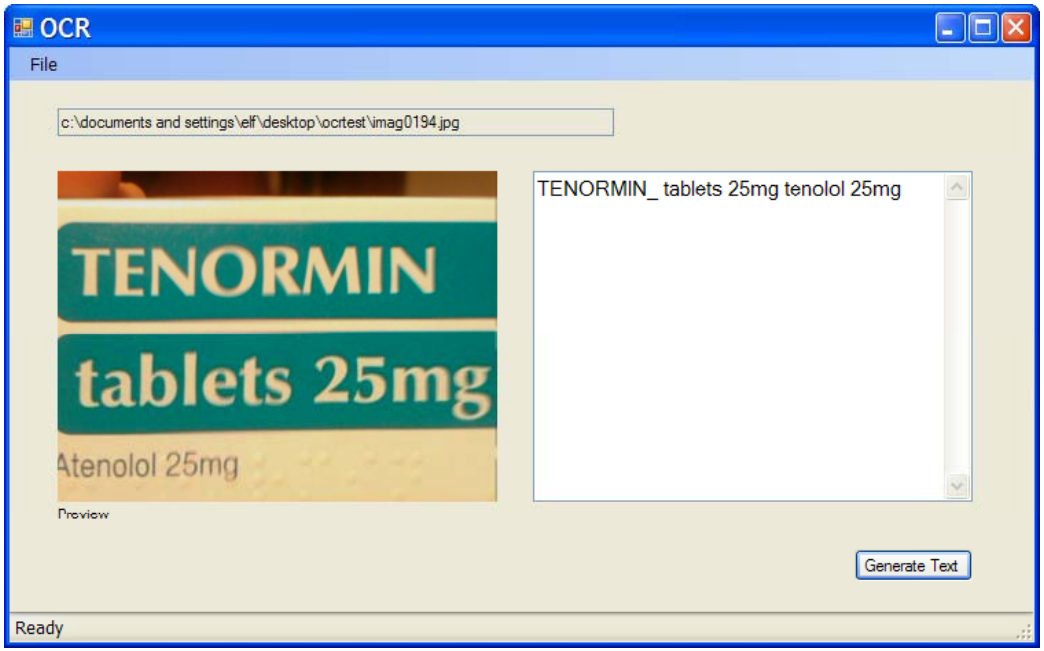
- 3 off-the-shelf algorithms for image comparison
- Weighted combination
- Precision ≈ 1m



An application to assist people with impaired vision

OCR using mobile phone's camera

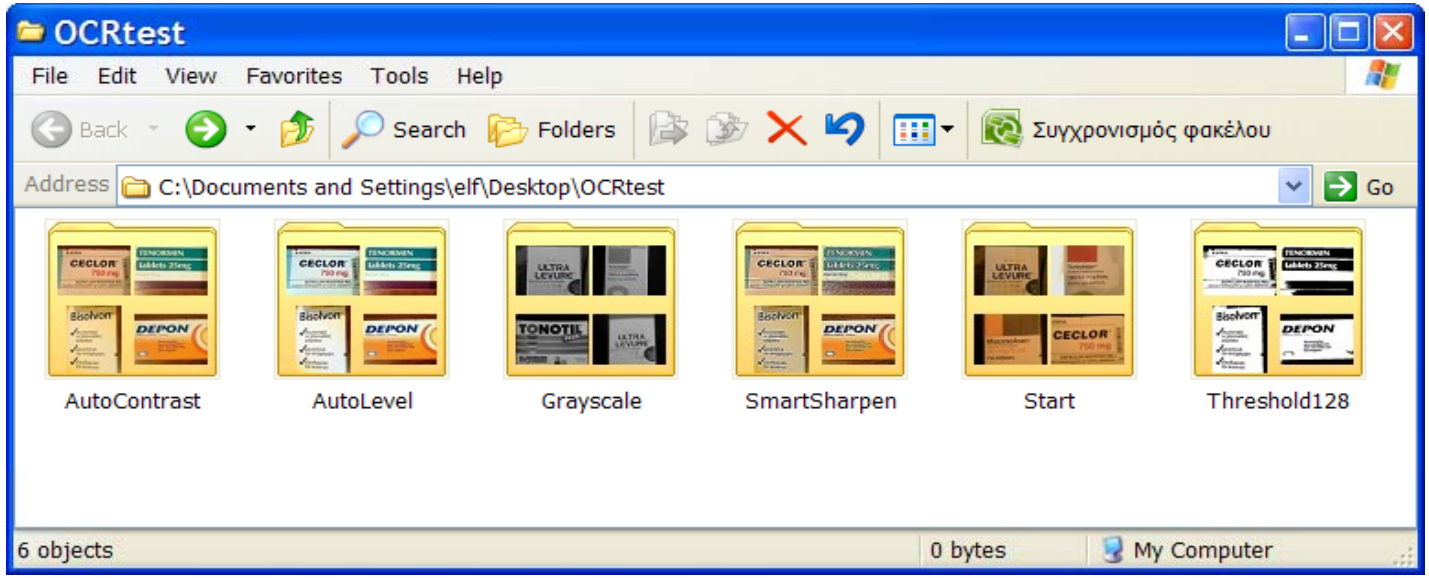
- Perform Optical Character Recognition (OCR) in photographs of medication boxes captured by smart phones or PDAs.
- Use of the Microsoft Office Document Imaging (MODI) object model that is available in Microsoft Office Document Imaging 2007



Effort to optimize the results (1)

Image processing techniques

- Contrast adjustment
- Level adjustment
- Grayscale
- Sharpness filter
- Threshold adjustment



Effort to optimize the results (2)

- Take advantage of an **a priori known medication list**
- Create an XML file with the names of medications used
- Perform OCR on the photographs of medication boxes
- Search for the exact name using the medication list
- If not found, calculate the similarity and return the best result (above a threshold)

```
<?xml version="1.0" encoding="utf-8"?>
<MEDICATION_LIST>
  <MEDICATION>
    <NAME>CECLOR</NAME>
  </MEDICATION>
  <MEDICATION>
    <NAME>TENORMIN</NAME>
  </MEDICATION>
      .
      .
      .
```

Results

Positioning

- db of 200 images
- ≈ 1m precision
- ≈ 70% success

OCR

- original photos ≈ 55%
- processed photos ≈ 62%
- medication list ≈ 81%

Summary and Conclusion

Indoor positioning

- Proposed a fingerprint-based localization system that uses images captured by the mobile phone
- Achieved a first step towards indoor monitoring (≈70% accuracy) at low cost in order to:
  - provide a secure environment
  - discover patterns in daily behavior of elderly and provide automated services

Future work

- Check room-level / quarter-room-level accuracy
- Find a better weighted combination of algorithms
- Take advantage of the timestamp metadata to predict location
- Combine with another monitoring system (e.g. Bluetooth)

Summary and Conclusion

OCR on photographs of medication boxes

- Proposed an application that helps people with impaired vision
- Other uses except medication
- No other related work

Future work

- Build an application that needs less user involvement
- Evaluate the performance using photos captured by next generation cameras (performance - lighting conditions)

Thank you

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