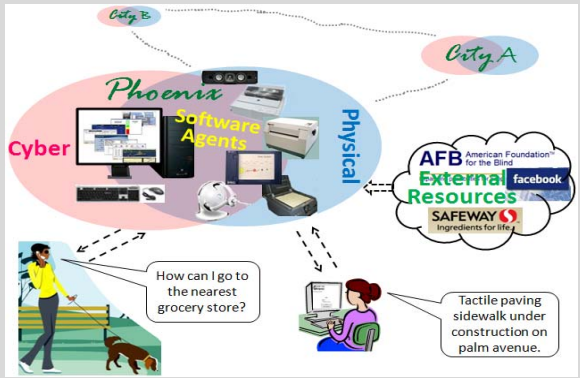
GoingEasy® with Crowdsourcing – Building Cyber-Physical Systems for People with Visual Impairment

Introduction

- **The problem:** Persistent barriers and widening digital divide faced by people who are blind in the social media era.
- **The challenges:**
  - Disparity in information-sharing among the visually impaired.
  - Limited understanding and study of the disparity.
  - Lack of methods and tools for effectively addressing these issues.
- **The project goal:** To design methodologies and develop computational tools for building new cyber-physical systems for supporting people with visual impairment in pursuing independent and active life.
  - **A unique requirement:** The tight intertwining of physical and cyber systems plus active participation of the human users are the key to attaining the otherwise unlikely capabilities.
- **Key team members:**
  - Senior personnel: *Baoxin Li* (PI), School of Computing, Informatics, and Decision Systems Engineering (CIDSE); *Terri Hedgpeth* (Co-PI), ASU Disability Resource Center; *Huan Liu* (Co-PI), CISDE; Peng Zhang (Postdoctoral Researcher), CIDSE.
  - Graduate Students (current & active): *Parag Chandakkar, Devi Paladugu*, *Qiongjie Tian*.

A Motivating Example & Research Tasks



- **Key research and development tasks**
  - **Designing and building blind-specific CPS**
    - Blind-specific SNS; Delivering customized information.
  - **Developing enabling cyber-physical capabilities**
    - Information repurposing; User/Behavior modeling and prediction.

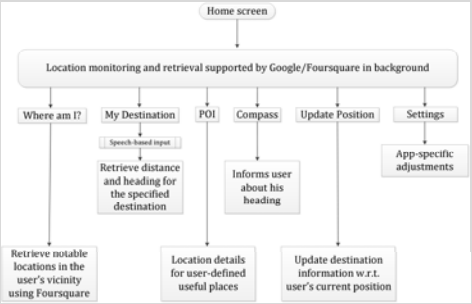
Current Progresses & Results

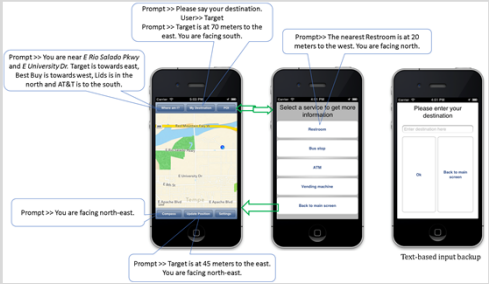
- **GoingEasy® Web services**
  - A fully functioning interface, supporting user registration and account management
  - Key functions:
    - Accessible on-line search of on-sale items from two local grocery stores.
    - Direction query with optional on-demand tactile map.
    - A blind-friendly forum for on-line discussion.
    - Mail function within the system
  - Advanced features: Adaptive interface based on usage modeling.

- **Developing a client-side smart-phone app (updated version)**
  - Objective: to support navigation of outdoor shopping complexes via a smart-phone-based client-side solution.
  - Unique challenges: lacking accurate GPS data; supporting real-time query; complex building/road configuration; accessible interface.
  - Three development cycles: Focus group study; Development of the actual app; End-user-based evaluation.

The new design illustrated

- Mapping information automatically obtained via fusing multiple sources.
- Speech-based input supported.





The actual iPhone app illustrated: different screens and their i/o streams.

- **Learning a quality metric for evaluating answers on a community question-and-answer site**
  - Objective: to develop a metric that can be used to compare answers and select the best answers on a CQA site.
  - Key approaches: Using relative learning, which facilitates use of relatively labelled data (which are easier to obtain); Explicitly taking into consideration correlations among all answers.
  - q_k denotes a question, $A_{k,i}$ denotes an answer to q_k .
  - actual app; End-user-based evaluation.
  - The formulation:

$$\min \frac{1}{2}\|w\|_2^2 + C_1\sum\xi_{i,j,k} + C_2\sum v_{k,i} \quad s.t.$$
$$w^T\Phi(q_k, A_{k,i}) \geq w^T\Phi(q_k, A_{k,j}) + 1 - \xi_{i,j,k} \;\; \forall k,i,j$$
$$w^T\Phi(q_k, A_{k,i}) \leq v_{k,i} \;\; \forall k,i\,, \xi_{i,j,k} \geq 0 \quad \forall i,j,k, v_{k,i} \geq 0 \;\; \forall k,i$$

- **Towards supporting interpretation of user-uploaded images**
  - Objective: to develop the capability of supporting a verbal description of a user-uploaded picture, in terms of semantic labels for the constituent regions of the picture. This is meant to provided yet another incentive features to users of the site.
  - Key approach: a new CRF-like model built to learn semantic labelling from vast on-line images with only partial image-level labels.
  - Data: training set $T = \{I^j, j = 1, \cdots, N\}$. Each image I^j is over-segmented into super-pixels, $I^j = \left\{x_i^j, i = 1, \ldots, N_j\right\}$. The image-level labels set is Y^j. y_i^j denotes the unknown super-pixel-level label for x_i^j.
  - The model:

$$\varepsilon\left(\{y_i^j\}, \theta, \alpha\right) = \sum_{x_i^j \in I^j, I^j \in T} \left(\psi(y_i^j, x_i^j, \theta) + \gamma(y_i^j, Y_j)\right) + \alpha_1 \sum_{(y_i^j, y_{i'}^{j'}) \in S} \phi(y_i^j, y_{i'}^{j'}, x_i^j, x_{i'}^{j'})$$
$$+ \alpha_2 \sum_{(y_i^j, y_{i'}^{j'}) \in M} \phi(y_i^j\, y_{i'}^{j'}, x_i^j, x_{i'}^{j'}) + \alpha_3 \sum_{(y_i^j, y_{i'}^{j'}) \in V} \phi(y_i^j\, y_{i'}^{j'}, x_i^j, x_{i'}^{j'})$$

  - Current major results: for the MSRC21 dataset, the proposed method is able to outperform the existing state-of-art by about 11%.

Up-coming Efforts

- Improvement for the GoingEasy social networking site:
  - Integrating the above picture-interpretation module into the current site, so that a user may upload pictures for descriptions..
- New client-side capabilities :
  - Deploying the updated iPhone app for Tempe Market Place
  - Supporting user input to the GoingEasy services via mobile devices.
- Development of new algorithms for enhancing intelligent processing on the social networking site
  - User/Behavoir modeling under extremely sparse conditions.
  - Auto-routing of user questions and proactive probing answerers.

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