CAP6938-02
Plan, Activity, and Intent Recognition

Lecture 2:

Overview (cont);
Event Hierarchy Circumscription

Instructor: Dr. Gita Sukthankar
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Schedule: T & Th 1:30-2:45pm
Location: CL1 212
Office Hours (HEC 232):
T 3-4:30pm, Th 10-11:30am

Outline

- Recap of last lecture
- Homework for next week
- Application area: Quality of Life Technology
- General approaches
- Background
  - Types of planners
  - Circumscription/frame problem
- Event hierarchy circumscription (Kautz paper)

Reminder: course signup deadline Friday

Recap

- Course expectations
- Definitions of plan/activity/intent recognition
- Challenges
- Application areas
- Robocup domain

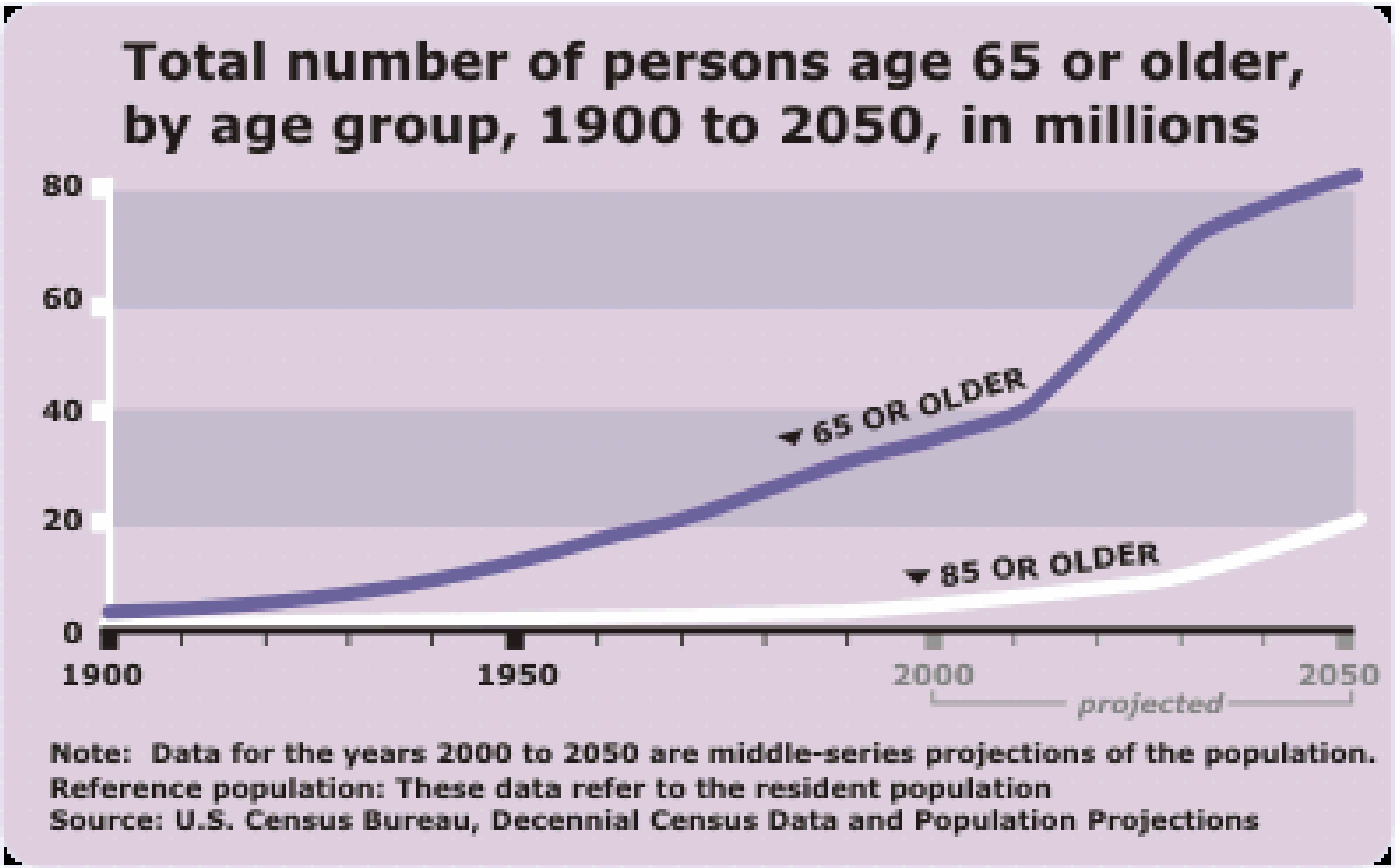
Homework for next week

- One page write-up of final project plan (due end of class on Thursday, Aug 30)
  - Should definitely include:
    - General overview of the problem you're trying to solve
    - Potential sources of data
    - A (vague) idea of approach/ hammers of interest
    - Your vision for a final demo
  - Optional: related work, evaluation procedure, references
- Oral presentation of plan (about 5 minutes, no power point required)
- Graded on a check/check+/check- basis
- Reading (on web page):
  - M. Tambe and P. Rosenbloom, Event tracking in a dynamic multi-agent environment, Technical Report ISI/RR-94-393, USC/Information Sciences Institute, 1994.
  - D. Avrahami-Zilberbrand and G. Kaminka, Fast and complete symbolic plan recognition. In Proceedings of IJCAI, 2005

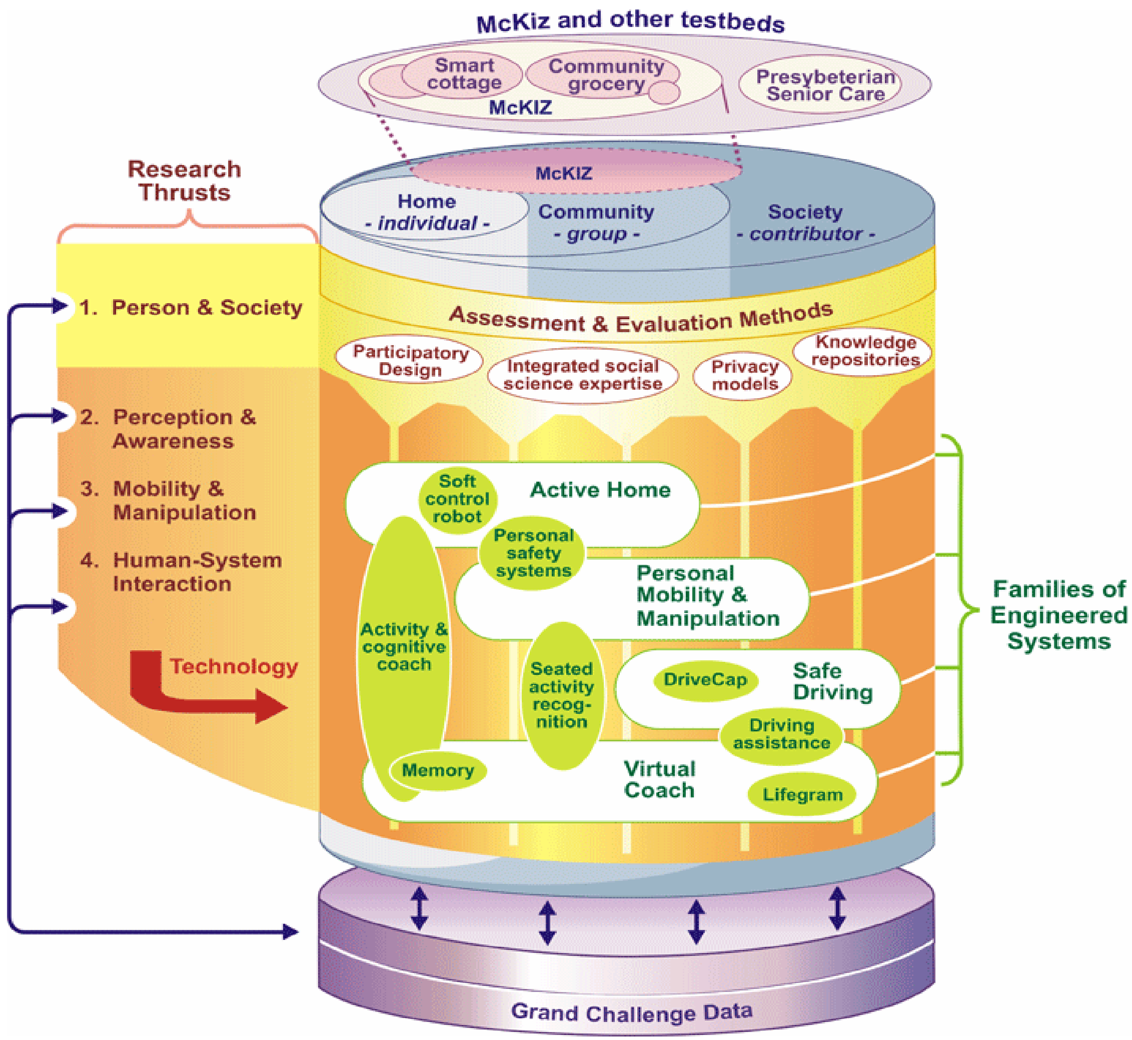
Elder Care Assistance

- If you're interested in doing a project in the area of smart homes/pervasive computing, consider focusing on elder-care assistance.
- Potential opportunity for students to present a poster of their work as part of an NSF site visit to the Quality of Life Technology Center (www.qolt.org) at CMU
- Get to visit Pittsburgh in Feb! ☺

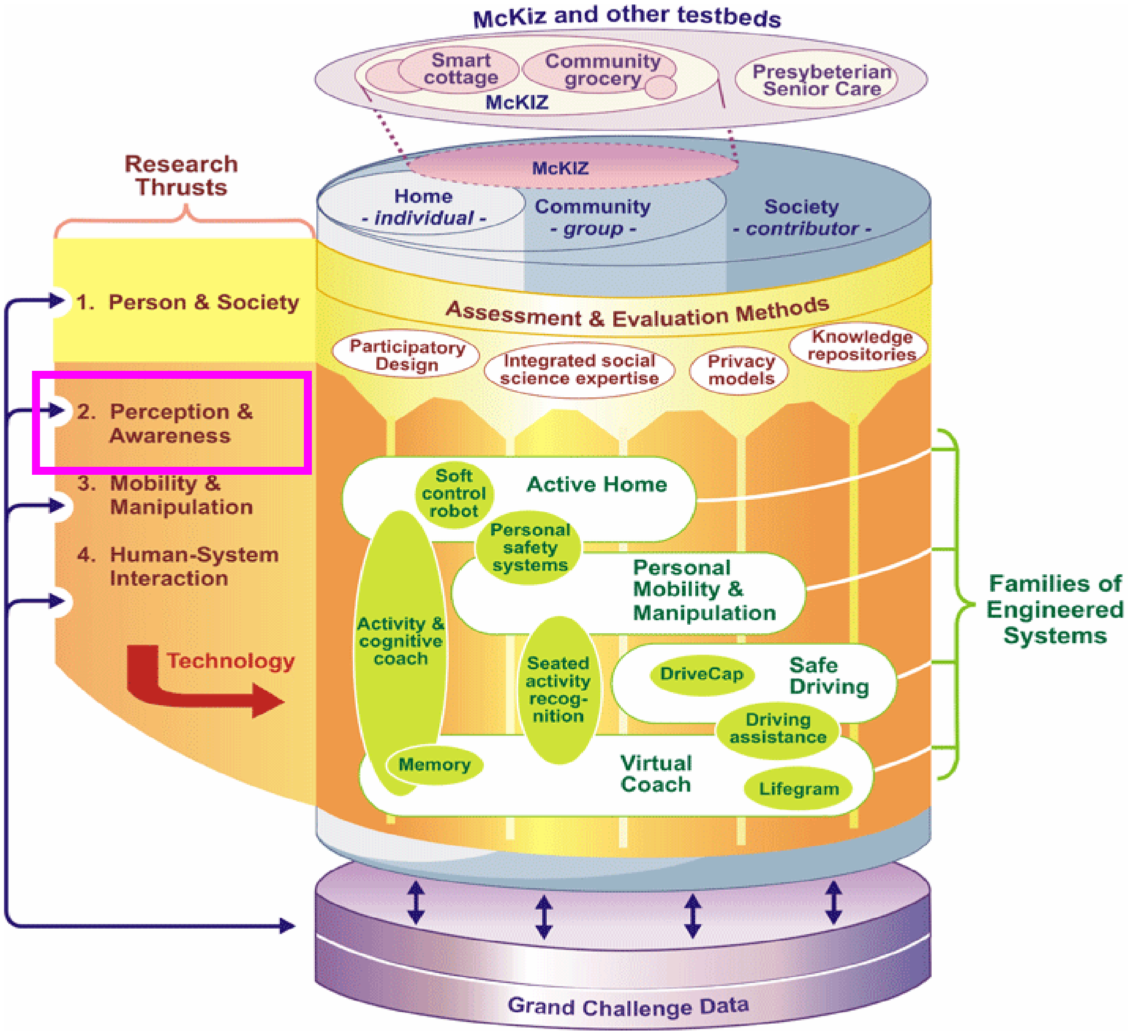
Aging Population



Quality of Life Technology Center



Quality of Life Technology Center



- User centric: system must understand user's intent
- Data-driven learning: models should be learned from data
- Multiple-data sources: combining data from multiple types of sensors

Possible Projects

- Intelligent medicine cabinet
  - Reminds user when to take their medicine
  - Monitors user's actions to ensure safe drug dosages
  - Suggests correct course of action after incorrect dosages have been taken
- Activity coach
  - Designed for users with mild memory impairment
  - Recognizes household activities (vision-based, wireless tracking data)
  - Coaches user through household activities like cooking and using appliances
- Driver assistance systems

General Approaches to PAIR

- Symbolic (consistency-based)
- Probabilistic (likelihood-based)
  - Graphical models (using graphs to represent joint probability distributions)
- Decision-theoretic (utility-based)
  - Game-theoretic (examining players, strategies, payoffs)

Symbolic (Consistency-based)

- Based on the idea that plan recognition is a consistency-checking process.
- A model matches the set of observations if the observed actions don't violate any of the constraints specified in the plan library.
- Example techniques (first 2 weeks of reading)
  - Event hierarchy circumscription (Kautz)
  - Event tracking/model tracing (Tambe)
  - Fast/complete symbolic plan recognition (Kaminka)
- Output: return complete set of models that pass consistency checking

Probabilistic (Likelihood-based)

- Based on the idea of selecting the plan that has a high probability based on the observed evidence
- Belief is usually calculated using some variant on Bayesian belief update (but Dempster-Shafer evidential reasoning has also been used)
- Includes both directed/undirected graphical model based procedures
  - Examples: dynamic Bayes networks (DBNs), hidden Markov/semi-Markov models (HMMs), conditional random fields (CRFs)
- Output: model with the maximum likelihood at the current time step given the set of previous observations

Decision-theoretic (Utility-based)

- Based on the idea that the agent is rational and acts to maximize a known utility function.
- Plan recognition process occurs by calculating utility of all plans in current situation.
- Game-theory is applicable for adversarial reasoning when the agent is simultaneously trying to maximize their utility while minimizing their opponents.
- Output: a rank-ordering of models by utility
- Note: this method is well-suited for prioritizing or pruning the search process and is often used in combination with one of the previous methods

Other Issues

- Layered architectures and hybrid approaches
- Format of plan library
- Exact vs. approximate inference
- Learning/estimating model parameters from data
- Use of domain-specific heuristics

Types of Planning

- Decompositional planner
  - (e.g. Hierarchical Task Network planners)
- State/action space is large/ill defined
- Plans are set of predefined recipes for action
- Reach goal by completing recipe
- Small search space

- Forward-chaining/state-space
  - (e.g. path planners)
- Well-defined set of action primitives
- Often uses heuristics for evaluating nearness of state to goal
- Large search space
- Relevant to: goal recognition

Circumscription/Frame Problem

- **Circumscription**
  - A type of non-monotonic logical procedure to formalize the common-sense assumption that things are expected unless otherwise specified
- **Frame problem**
  - Formulated as the problem of expressing a dynamical domain in logic without explicitly specifying which conditions *are not* affected by an action
  - Discussed in the Robot's Dilemma (Pylyshyn)

(definitions from Wikipedia)

Event Hierarchy Circumscription

- Strengths?
- Weaknesses?
- Application areas?

H. Kautz, A Formal Theory of Plan Recognition and its Implementation, in Reasoning about Plans

Event Hierarchy Circumscription

- Good points:
  - Very general; no domain specific heuristics
  - Spells out the closed-world assumptions that are implicitly used by many recognition systems
  - Uses deductive inference so could be implemented using a general purpose theorem prover (depending on the general axioms)
- Bad points
  - Inference procedure is poor (slow and undecidable)
  - Most applications don't care about "justifying inferences"; care about completeness (or if incomplete, precision/recall)
  - Weak at handling temporal constraints

Next Time...

- Discuss paper:
  - M. Tambe and P. Rosenbloom, Event tracking in a dynamic multi-agent environment, Technical Report ISI/RR-94-393, SC/Information Sciences Institute, 1994
- Do about half the in-class presentations