


Probabilistic and decision-theoretic user modeling in the context of software customization



Depth oral presentation
Department of Computer Science
University of Toronto

Bowen Hui
bowen@cs.utoronto.ca

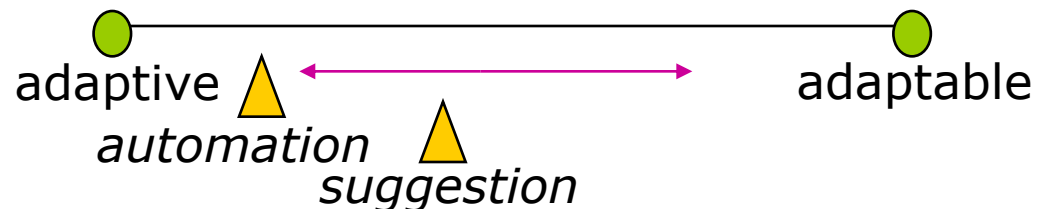
Need for software customization

- current state of practice: one-size-fits-all
- result:
 - bloated software, cluttered interfaces, closet-ware, user *dissatisfaction*
- most affected users
 - novices
 - children
 - elderly people
 - people with cognitive, sensory, motor impairments

Software customization (SC)

- customize interface or functionality
- requirements of diff user groups [HLM03]
 - customize software based on user goals
 - ranked alternatives with preferences + skills
 - generated customization at *design time*
- customize at *run time*
 - adaptable – user control
 - adaptive – system control

□ continuum:

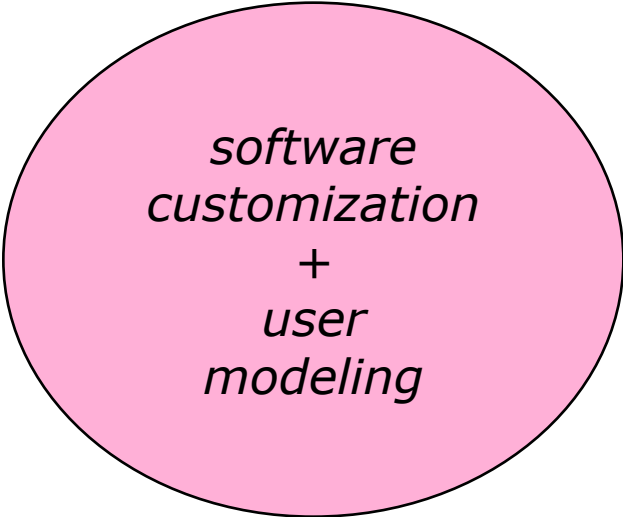


Aspects of SC

- user profile
 - goals
 - preferences
 - skills
 - user traits
- uncertainty
- cost modeling
 - expected value of information (EVOI)
- sequential reasoning
- unobservability

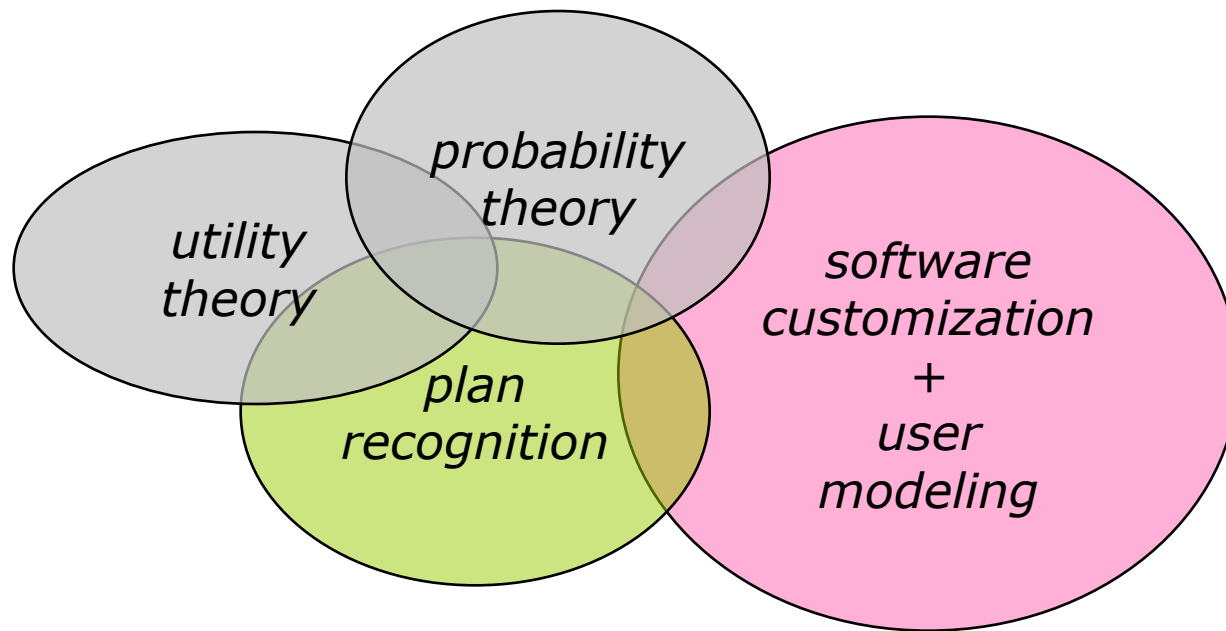
probabilistic and decision-theoretic modeling

General literature landscape

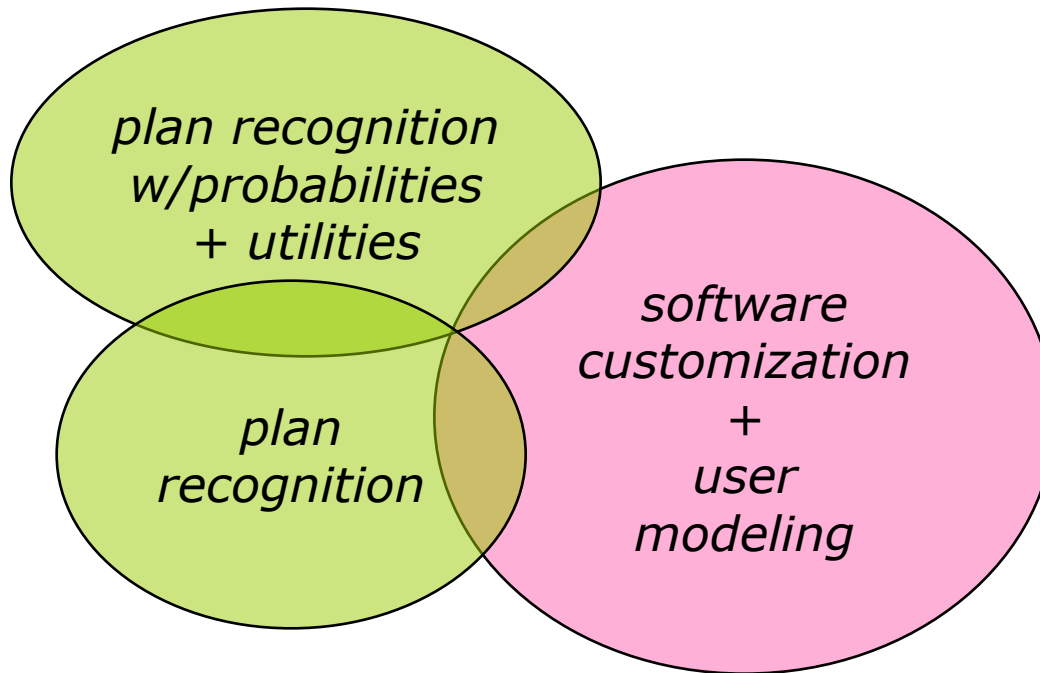


*software
customization
+
user
modeling*

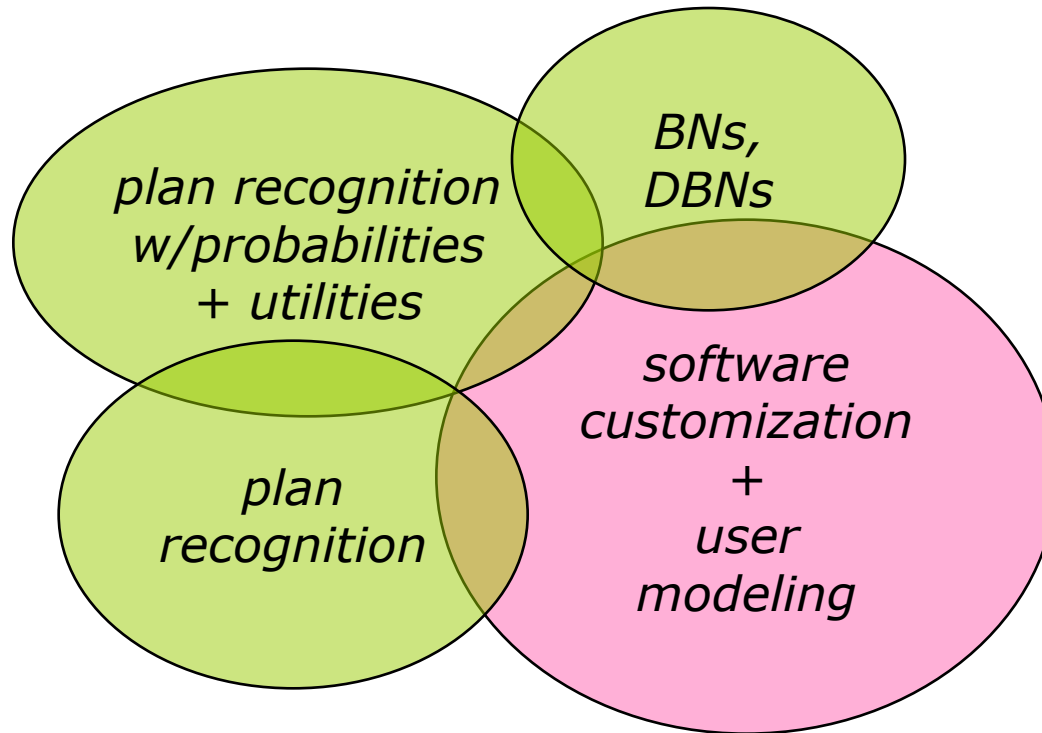
General literature landscape



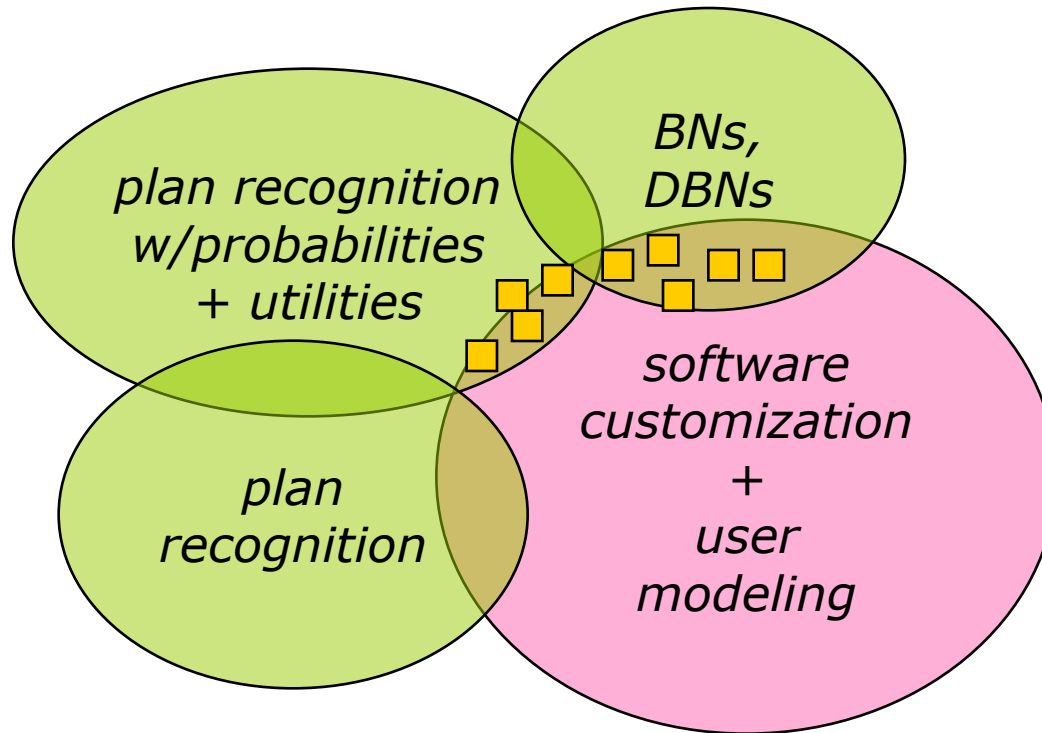
General literature landscape



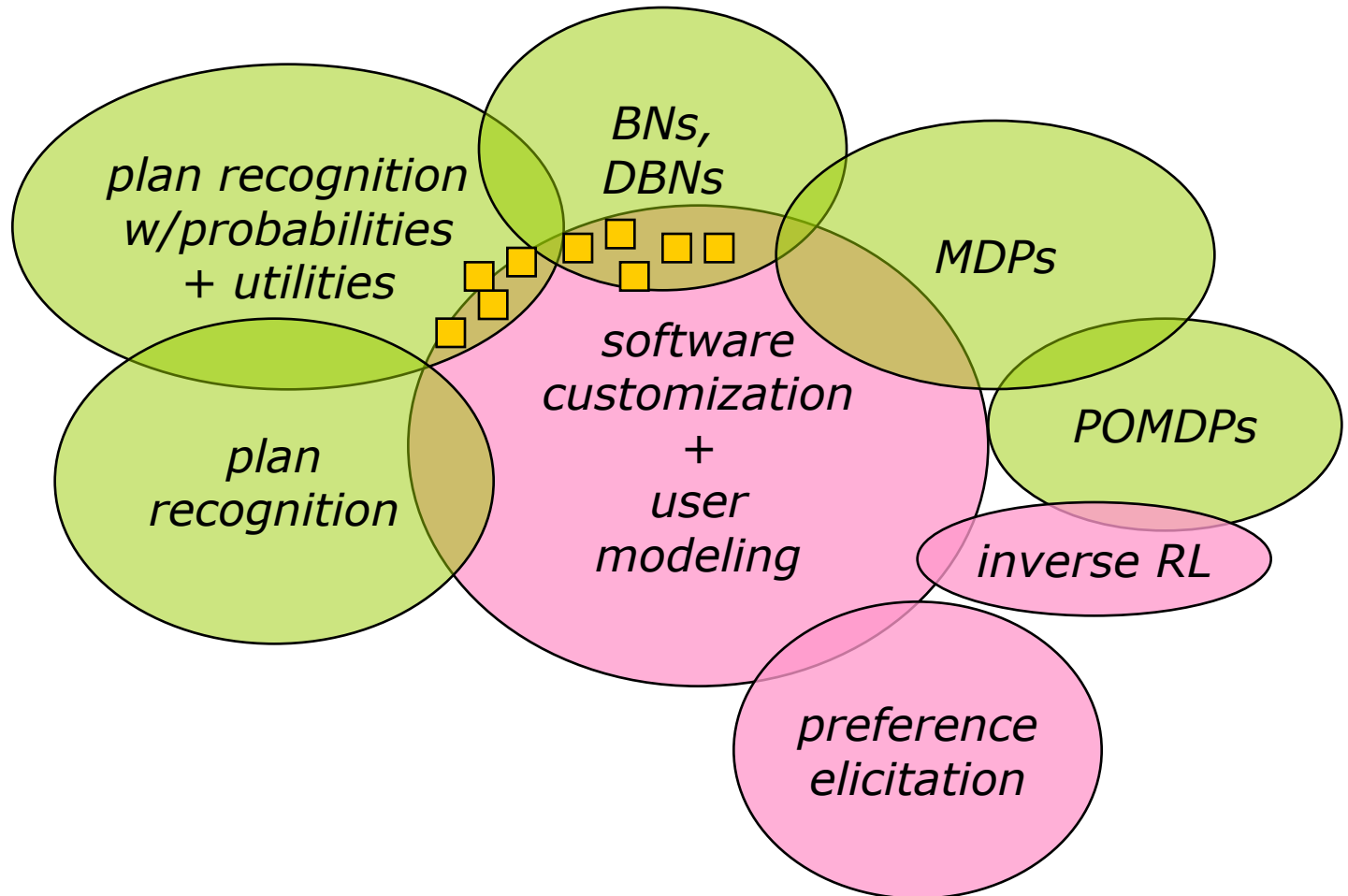
General literature landscape



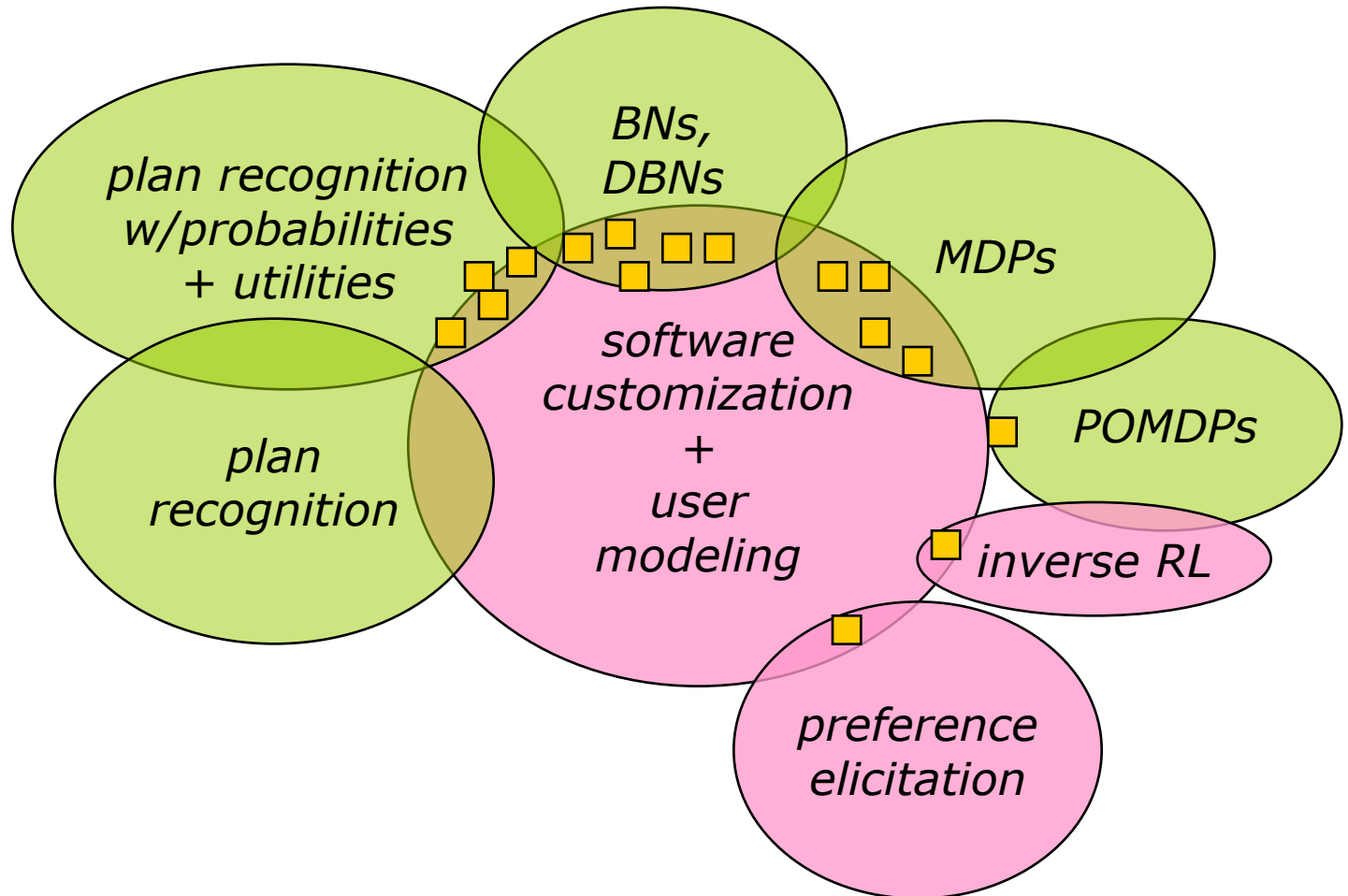
General literature landscape



General literature landscape



General literature landscape

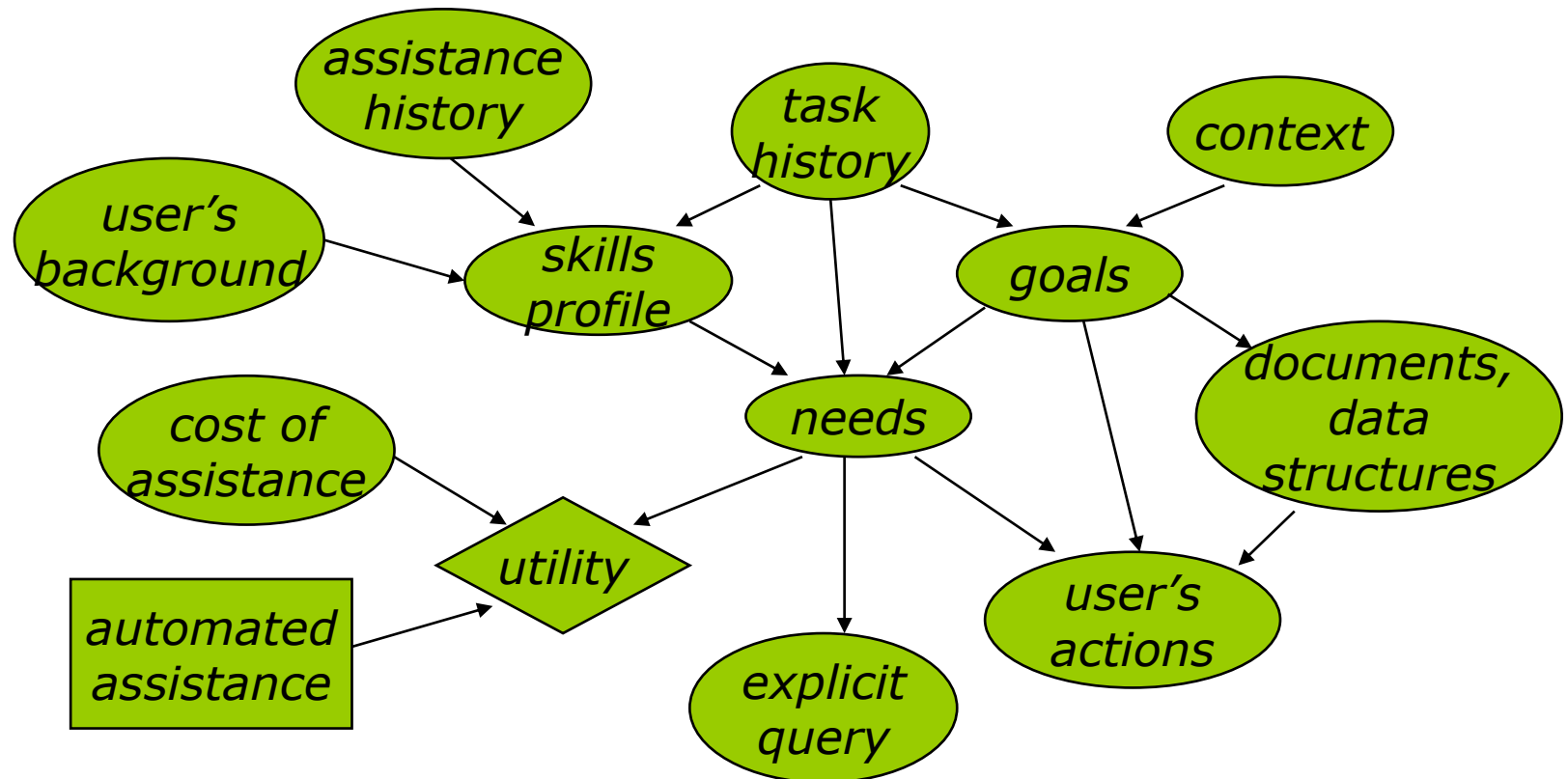


System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, **Lumière: HBH+98**, Hor99

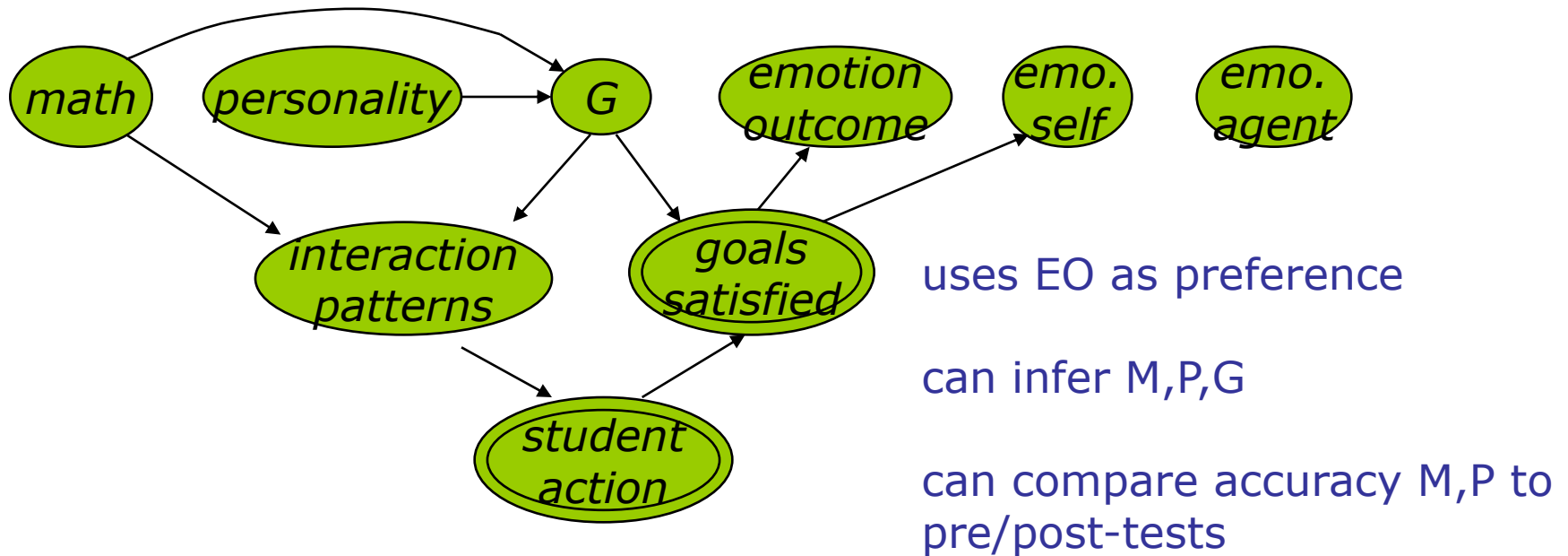


System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, **OCC in Prime Climb: ZC03**



System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, LFL98, CV01, MV00, ZC03, HBH+98, Hor99

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, LFL98, **CV01, MV00, ZC03, HBH+98, Hor99**



Bayesian:

- *model causal influences*
- *belief distribution*
- *update beliefs in principled way*

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - HBH+98, Hor99

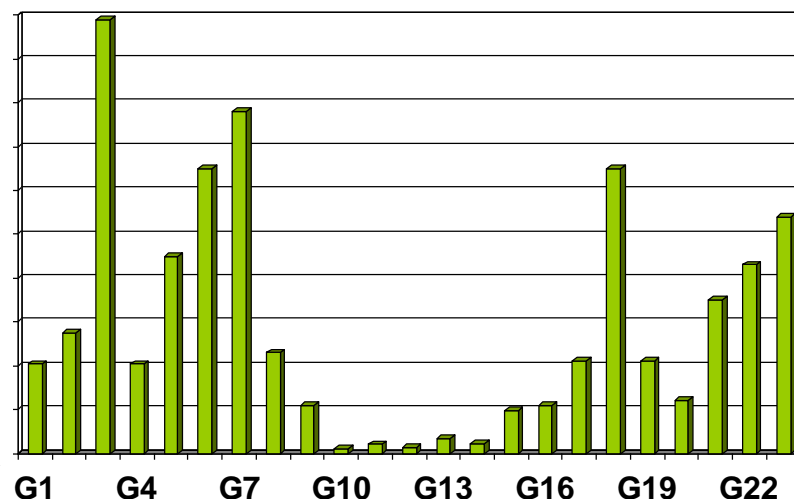
System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - **Lumière: HBH+98**, Hor99

infers: N:  35%

- Pr(need help now)
- Pr(goal)

action:
- help if $\text{Pr}(N) > \text{threshold}$



System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - HBH+98, Hor99
- cost modeling
 - FC01, GW04, LFL98, MV00, Hor99

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - HBH+98, Hor99
- cost modeling
 - FC01, **Supple: GW04**, LFL98, MV00, Hor99

cost(interface) = navigation cost + manipulation cost, w.r.t. history

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - HBH+98, Hor99
- cost modeling
 - FC01, GW04, LFL98, MV00, **LookOut: Hor99**

outcomes:

$u(A, G)$ [best], $u(A, \neg G)$ [worst]

$u(\neg A, G)$, $u(\neg A, \neg G)$

$$EU(A) = Pr(G)u(A, G) + Pr(\neg G)u(A, \neg G), \quad EU(\neg A) \text{ similarly}$$

System comparison

- goals, preferences, skills
 - FC01, BJB98, CV01, MV00, ZC03, HBH+98, Hor99
- user traits
 - CV01, MV00, ZC03
- uncertainty
 - FC01, BJB98, GW04, LFL98, CV01, MV00, ZC03, HBH+98, Hor99
- unobservability
 - HBH+98, Hor99
- cost modeling
 - FC01, GW04, LFL98, MV00, Hor99
- sequential reasoning
 - ?

What's missing

□ modeling

- estimate user traits
- expected value of information (except Hor99)
- user's utility function (except Hor99)
- non-myopic policies

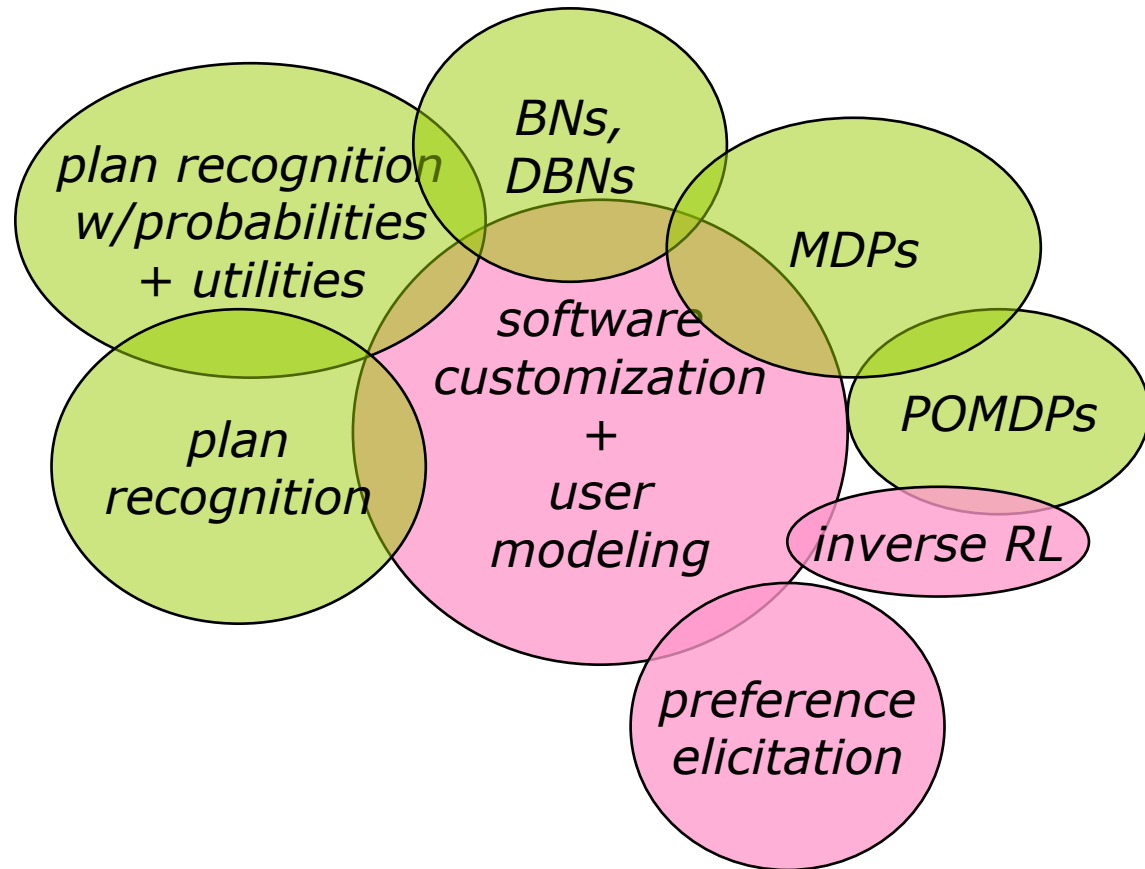
□ evaluation

- "convergence" of performance
- online performance
- usability

□ learning user's utility function

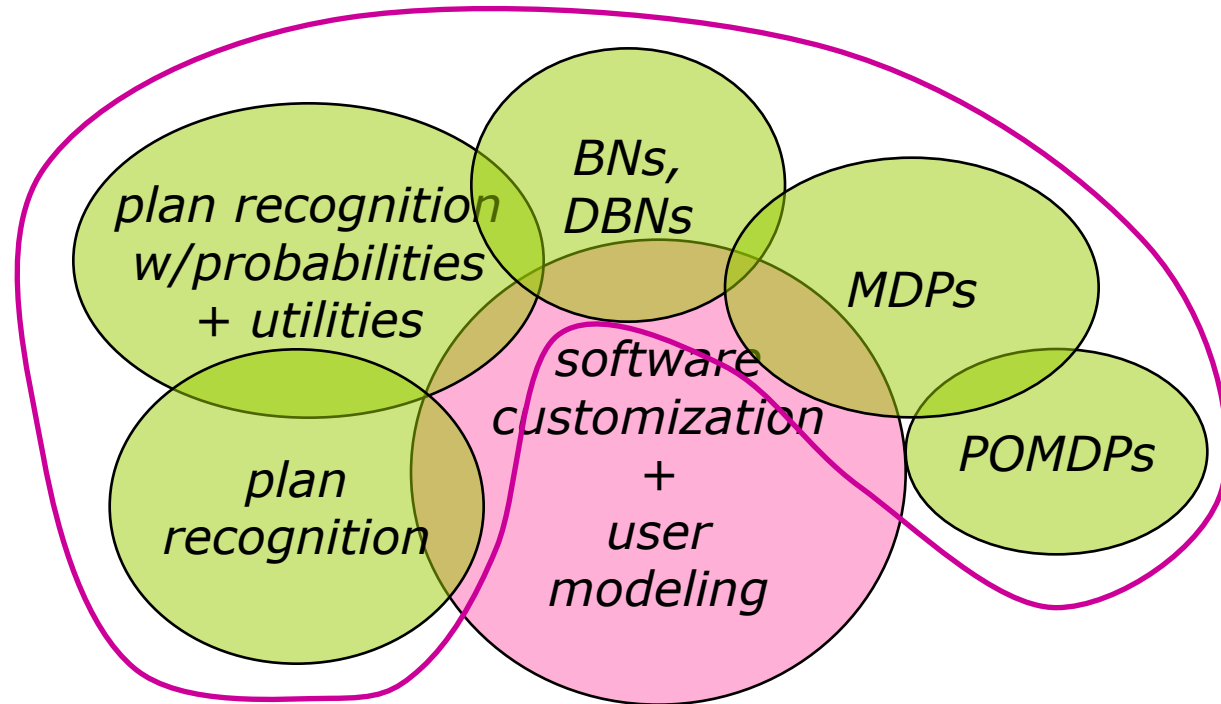
Underlying models

- goals, preferences, skills, traits
- uncertainty
- cost modeling
- sequential reasoning
- unobservability



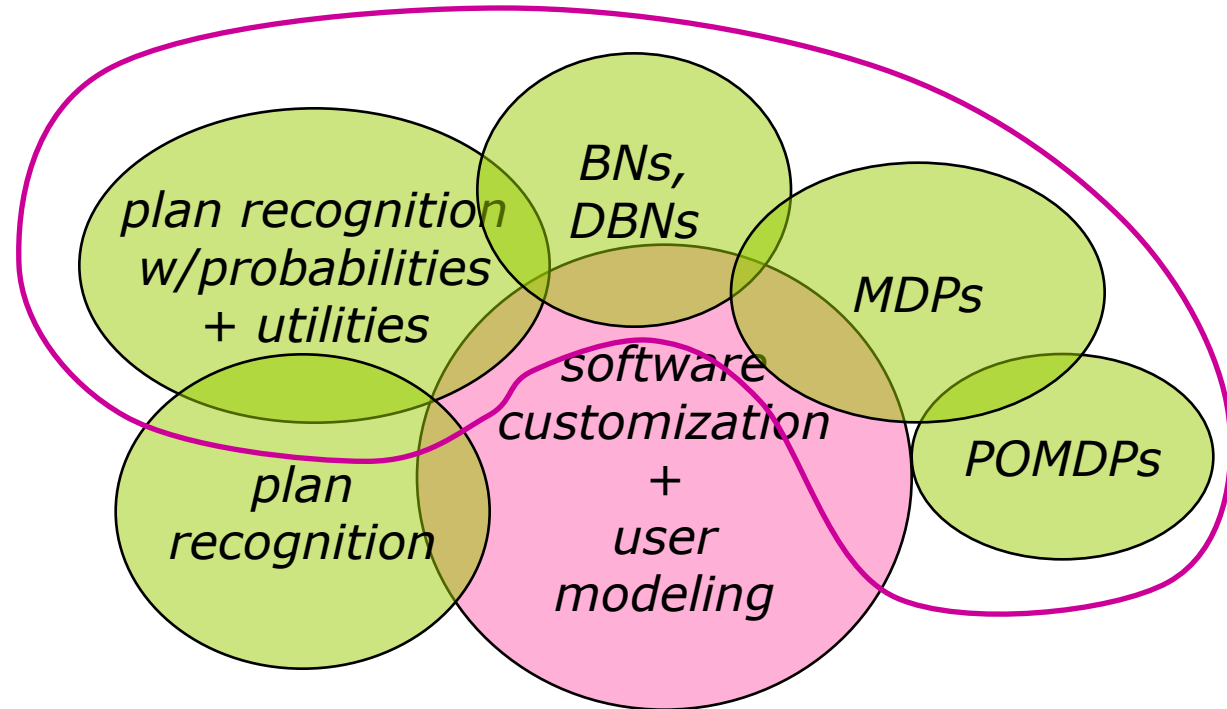
Underlying models

- goals, preferences, skills, traits
- uncertainty
- cost modeling
- sequential reasoning
- unobservability



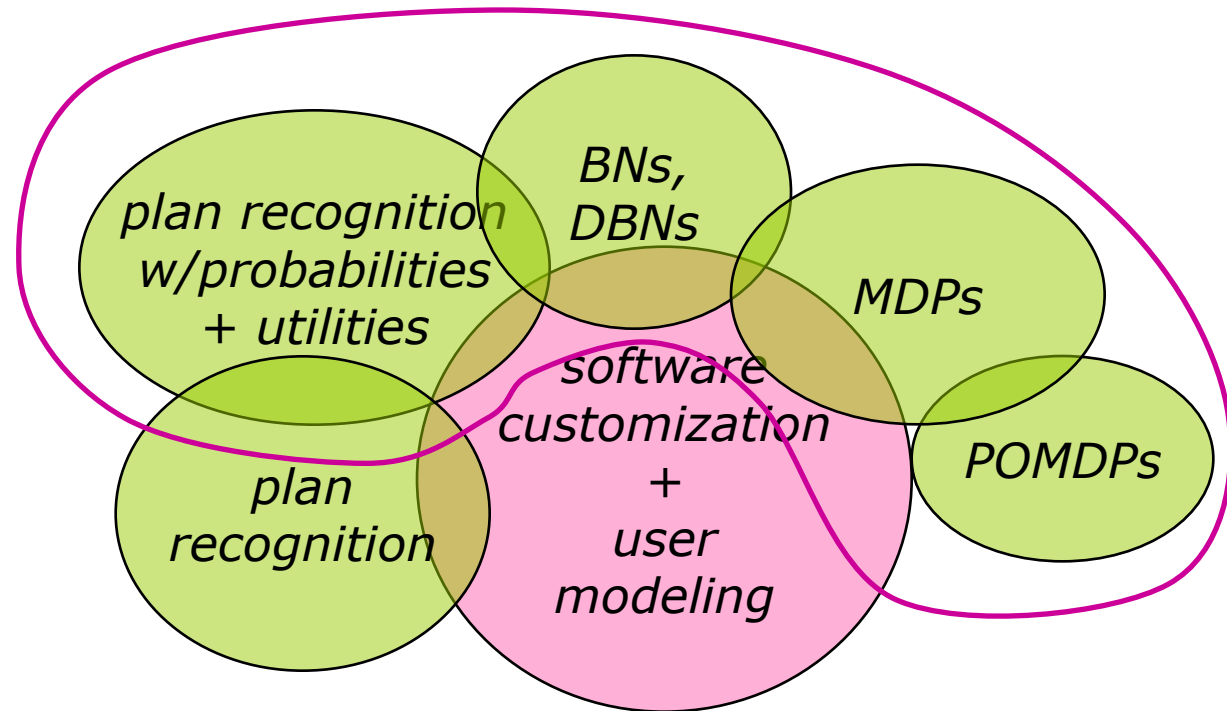
Underlying models

- goals, preferences, skills, traits
- **uncertainty**
- cost modeling
- sequential reasoning
- unobservability



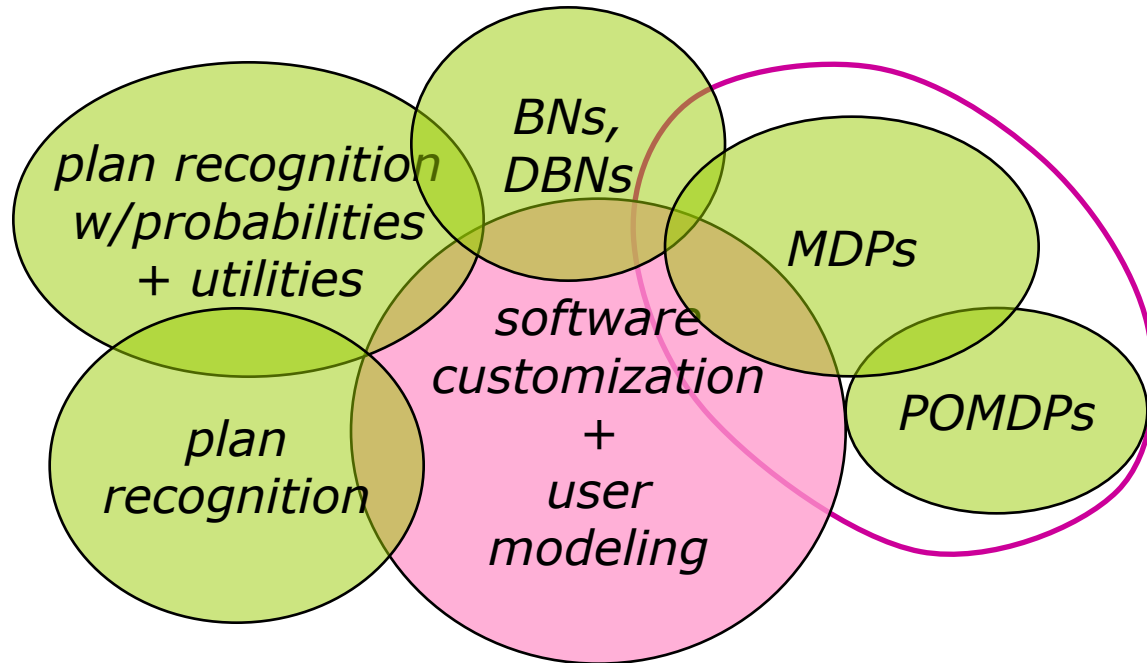
Underlying models

- goals, preferences, skills, traits
- uncertainty
- **cost modeling**
- sequential reasoning
- unobservability



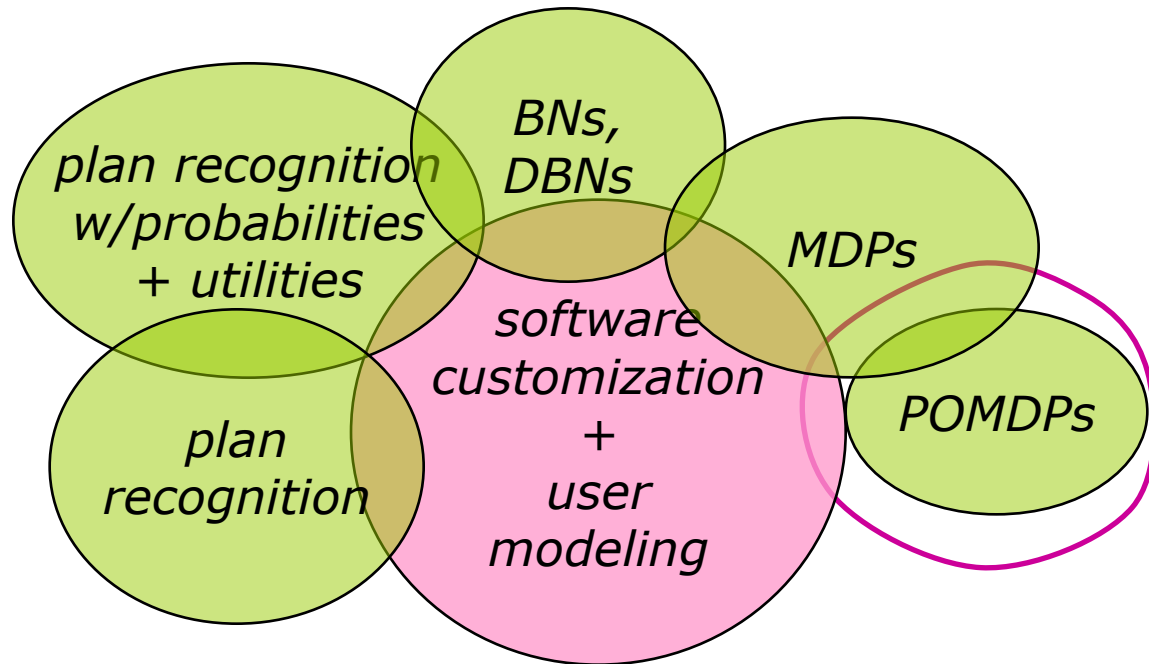
Underlying models

- goals, preferences, skills, traits
- uncertainty
- cost modeling
- sequential reasoning
- unobservability



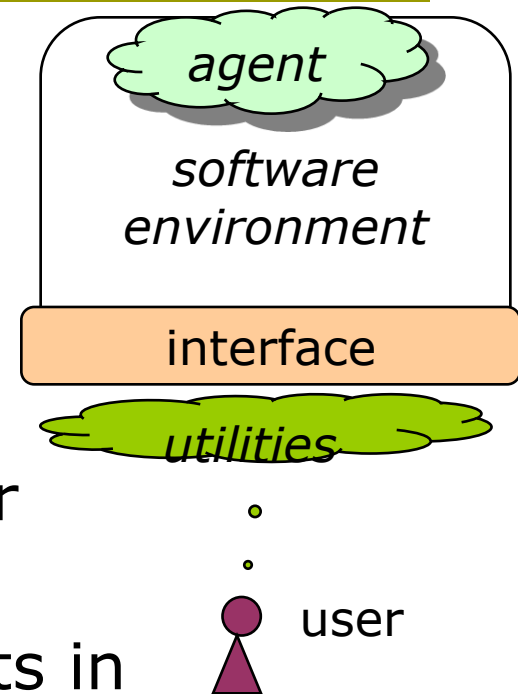
Underlying models

- goals, preferences, skills, traits
- uncertainty
- cost modeling
- sequential reasoning
- **unobservability**



Sequential decision making under uncertainty

- principled way of modeling SC
- user interacting with software
 - user has goals
 - user has reward/utility function
 - user “states” are unobservable
- opportunities for agent to assist user
 - every action has consequences
- model agent in environment who acts in expectation of the user’s utility function



partially observable Markov decision process
(POMDP)

Research directions

- typing assistant model
 - represent POMDP model as DBN
 - refine model simulations
 - collect user data to learn parameters T, O
- evaluation
 - “convergence”
 - online performance
 - usability
- learning user’s utility function
 - formulate as POMDP
 - constrain belief distribution (PE)
 - incrementally learn utility function (IRL)
 - adapt POMDP approximation algorithms