Intelligent Tutoring Systems

- Brief History
  - Computer Assisted Instruction
    - student steps through lesson on-line
  - Intelligent Computer Assisted Instruction
    - some customization of interaction as well
  - Intelligent Tutoring Systems
    - diagnose errors and model the learner
    - develop strategies for tutoring
  - Student Modeling
    - focus on how best to model the student, update the model and use the model to teach the student
    - subfield of user modeling

- Early Work:: BUGGY (Burton and Brown) (1982) student errors in arithmetic

  - errors seen as symptoms of a bug, modifications of correct skills

  - applied to subtraction domain; simple enough to diagnose errors, complex enough still

  - initially: prespecified set of bugs, choose bugs that maximally account for behaviour

  - bug = least possible variant of skill that mimics behaviour

  - problem: bugs may be related to each other

  - distinguish between primitive and complex bugs

- complications
  - mistakes when tired or lazy: keep finding systematic errors, even in the presence of these exceptions
  - subskill variants: may do parts correctly where bug predicts incorrect
  - compound bugs: look at equivalence classes of bugs

- DEBUGGY system
  - initial hypothesis set: all bugs that explain at least one of student's wrong answers
  - reduce initial hypothesis set: remove primitive bugs subsumed by other bugs
  - with database of bugs: define subskills, place into a lattice
  - offer remediation associated with deficient skill set
  - develop methods for efficient search

- SCENT project (U. Saskatchewan; McCalla et al.)
  - help students with LISP programming
  - Scent1: no deep modeling of student's problem solving
  - Scent2: recognize strategies at different levels of granularity; knowledge base of misconceptions (analogies)
  - Scent3: distributed processes cooperating, each performing various aspects of program advising
    * monitoring student input
    * analyze student knowledge, strategies and misconceptions
    * designing instructions for student

- details of the system
  - student response analyst: examine programs generated by student, find strategies and bugs
  - implementation level analyst: functional equivalences between two segments of LISP code (discrimination network)
  - strategy judges: see if program is consistent with the ideal
  - student model manager: overlay model of what student knows
  - instructional planners: what to present to student and how, plans tailored to the student
  - instructional goals: allow student to learn concept or remove misconception
  - update student model after responses and propagate instructional goals, based on responses

- different approaches to teaching used (VCR example)
  - option 1: tell student what to do
  - option 2: tell student "right" or "wrong"
  - option 3: allow wide variety; quiet if student doing well, tell student what to do if wrong
  - option 4: cognitive study in advance; modeling classes of users, possible misconceptions, provide advice based on perceived level

- lessons learned
  - granularity-based reasoning useful, adding knowledge made a difference
  - plan recognition is challenging
  - users are unpredictable (not like in expert systems)
  - useful to alllow student-driven hints
  - useful to tailor output to student
  - students are different users, are trying to communicate and are content to be modeled

Other advances in AI and Education

- collaborative learning and peer to peer help systems (U Saskatchewan)
- mixed-initiative intelligent tutoring systems
  - user or student can decide to move on
  - user can request help on demand
  - system can step in to respond to silence
  - active learners learn better (Carberry)
  - usually: system determines what parts of domain are explored, order of topics and way of presentation; user conveys lack of understanding or just answers questions
  - better way: student and system collaborate on content of tutorial dialoigue; student may have some knowledge but not know how to integrate it
  - need to reduce unrestricted initiative from students
    - student can't understand or may alter agenda
  - applications: TRAUM-AID used by medical students, kids learning to read