Do what I mean: Teaching computers to automate repetitive tasks

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Why is PBD hard?
- Huge space of potential programs
- Very small number of examples
- Prediction must be highly accurate
  - Amounts to understanding user’s intent
- Prior approaches: domain-dependent heuristics
- My work: Machine learning approach to PBD

SMARTedit demo

SMARTedit’s version space

How SMARTedit works
- Action is function : input state → output state
  - Editor state: text buffer, cursor position, etc.
  - Actions: move, select, delete, insert, cut, copy, paste
- Given a state sequence, infer actions
  - Many actions may be consistent with one example
SMARTedit's version space

Expression action functions in terms of locations

Location functions map from text state (buffer, pos) to position

Rectangle indicates atomic (leaf) version space

How does the system learn?
- Update version space on new example
  - Remove inconsistent hypotheses
  - Prune away parts of the hierarchy
  - Execute version space for prediction
  - Give system current state
  - What state would the user produce next?

Updating the version space
- Test consistency of example against entire version space
- Quickly prune subtrees
- Example:

Updating the version space
Executing the version space

\begin{align*}
\text{Row} & \quad \text{Col} \\
4 & \quad 2.5 & 5 & \quad 0.2 \\
\end{align*}

\[
f(x) = 2 \quad f(x) = x + 1 \\
g(x) = 0 \quad g(x) = x - 3
\]

Getting your priors straight

- How to choose between possible outputs?
- Associate probability w/ ea hypothesis
- Make better predictions
- Introduce domain knowledge
- Introduce probabilities at two points in hierarchy:
  - Probability distribution over hypotheses at leaf nodes
  - Weights for each VS in a union

User study results

- 6 undergrad CS majors
- 7 repetitive tasks with & later w/out SMARTedit
- Tasks: 4 to 27 iterations, 1-5 min to complete
- Evaluation metrics:
  - Time saved completing task with SMARTedit's help
  - % user actions (keyboard + mouse) saved
  - User feedback

Experimental results

Very few examples needed!

Results indicate examples that must be demonstrated, out of total number of examples

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Percentage action savings with SMARTedit

\[
\frac{m - s}{m}
\]
Research at an industry lab

- My history:
  - BA/BS in Computer Science & Applied Physics at Cornell University, 5/1995
  - PhD in CS at University of Washington, 5/2001
  - Research Staff Member at IBM Research, 9/2001
- Challenge: find balance between
  - Research that benefits IBM
  - Long-term scientific advances
  - Personal interest and motivation

How can IBM make use of PBD?

- Vision: programming by demonstration can change the world!
- Desk-side technical support: reduce cost of system administration
  - Troubleshooting network connectivity
  - Installing IBM software
- Automated business procedures
  - Requesting travel reimbursement
  - Buying a new workstation
  - Personal productivity

Sheepdog demo

Learning from multiple traces

- Align similar steps in procedure:
  - expert #1: [steps]
  - expert #2: [steps]
- Build procedure model:

What happens next?

- Finding path to impact
  - Web platform more aligned with IBM strategy than Windows platform
  - Learning about web-based server installation and configuration
- Continuing on with research
  - Adding more domain knowledge, as in SMARTedit
  - Learning actions with variable parameters
  - Defining metrics to evaluate usability and system performance