Program Synthesis

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Program Synthesis is the task of searching for a program in some underlying domain-specific language that matches the user's intent. These lectures will describe three key dimensions in program synthesis.

- User Interaction Model: The user may specify the intent using examples, demonstrations, logical specifications, keywords, natural language, sketch, or partial/inefficient programs. A key challenge here is to design a user interaction model that can deal with inherent ambiguities in underspecifications.
- Search technique: We will cover techniques that have been developed in various communities including use of SAT/SMT solvers (formal methods community), version space algebras (machine learning community), and A^*-style goal-directed heuristics (AI community).
- Domain specific language: This can range from straight-line programs to programs with restricted form of loops/conditionals/events.

These dimensions will be illustrated via a variety of applications in Algorithm discovery (e.g., Bit-vector algorithms) and End-user programming (e.g., Spreadsheet macros, Drawing macros, and Smartphone scripts). We will also present some surprising applications in the area of Computer- aided education including problem generation, solution generation, automated grading, and content creation for a variety of subject domains including math, logic, and programming.

Reading List:
The following papers provide a good sampling of the above material.

- Version Space Algebras [2]: This paper showcases a *cross-disciplinary methodology* to enable a usable program synthesis system, which was released as the Flash Fill feature in Excel 2013 [1]: Design of an appropriate domain-specific language, data-structures and algorithms to represent and compute sets of programs, machine learning to rank programs, and user interface design to enable ease of use.
- Active Learning [4]: This paper describes an *interesting example-based interaction model* to resolve ambiguity in example-based under-specifications.
- Geometry Constructions [3]: This paper shows an *interesting application of program synthesis* to the area of computer-aided education.

References

[1] Flash Fill (Microsoft Excel 2013 feature).
`http://research.microsoft.com/users/sumitg/flashfill.html`

[2] S.Gulwani. *Automating String Processing in Spreadsheets using Input-Output Examples.* In: POPL, 2011.

[3] S.Gulwani, V.A.Korthikanti, A.Tiwari. *Synthesizing Geometry Constructions.* In: PLDI, 2011.

[4] S.Jha, S.Gulwani, S.A.Seshia, A.Tiwari. *Oracle-guided Component-based Program Synthesis.* In: ICSE, 2010.