EECS 598-008 & EECS 498-008: Intelligent Programming Systems

Lecture 1: Course Overview

Clarifications

- EECS 598-008: Graduate, in-person
- EECS 498-008: Undergraduate, in-person
- EECS 598-098: Graduate, remote (for students who cannot arrive in the US)
- EECS 498-081: Undergraduate, discussion section

- If you're a graduate in the US, you should register 598-008, even if you envision you may miss a few lectures (and that's totally fine)
- 498-081 (discussion)
  - Some may convert to remote office hours (see schedule on course page)
  - Optional, but highly recommend
- All office hours, both instructor's and GSI's, will be remote
  - https://oh.eecs.umich.edu/courses/eecs-498-598-008

COVID-related Course Policies

- Masks **required**. [1]
- Proof of vaccination/weekly testing **required**. [2]
- Social distancing (6 ft/1.8m) **highly recommended**. [3]

- Whenever not feeling well/uncomfortable attending in-person, skip in-person lectures.
- All in-person lectures are recorded and available afterwards.
- Remote live lectures available.
- Remote student presentations could be an option, but more details forthcoming.
- In case instructor cannot lecture in person, convert to remote or reschedule to another time.

[1] https://ehs.umich.edu/wp-content/uploads/2020/07/U-M-Face-Covering-Policy-for-COVID-19.pdf?utm_source=Engin+Update+Fall+2021&utm_campaign=dde963167e-EMAIL_CAMPAIGN_2018_12_13_02_33_COPY_01&utm_medium=email&utm_term=0_77986d5a13-dde963167e-278510492

[2] https://record.umich.edu/articles/u-m-outlines-accountability-measures-for-covid-19-vaccine-policy/

[3] https://ehs.umich.edu/wp-content/uploads/2021/06/COVID-19-Guidelines-for-Campus-Facilities.pdf?utm_source=Engin+Update+Fall+2021&utm_campaign=dde963167e-EMAIL_CAMPAIGN_2018_12_13_02_33_COPY_01&utm_medium=email&utm_term=0_77986d5a13-dde963167e-278510492

Tools Used in This Course

- https://web.eecs.umich.edu/~xwangsd/courses/f21/index.html: schedule, dues, recordings, slides, etc.
- Slack: ad-hoc questions/discussions, quick announcements
- https://oh.eecs.umich.edu/courses/eecs-498-598-008: office hours
- Canvas: mostly assignment/report submissions
- HotCRP (https://umich-eecs598-eecs498-fall-21.hotcrp.com/): offline paper reviews/discussions
- Email (ips2021umich@gmail.com): private messages to teaching staff (instructor & GSI)

- Instructor Email (xwangsd@umich.edu): private messages to instructor
- GSI Email (leozhu@umich.edu): private messages to GSI

Announcements

- First programming assignment A0 out today
- Friday discussion section —> remote office hour

Agenda

- **Introduce yourself**
- Course overview
- Logistics overview

Course Staff

- Instructor: Xinyu Wang
  - Assistant Professor in CSE (joined in September 2020)
  - Research: Computer Systems
    -> Programming Languages, Formal Methods, Software Engineering
    -> **Program Synthesis**/Analysis/Verification

- GSI: Yuanli Zhu
  - Masters student in CSE

Introduce yourself

- Name?
- What program? What year?
- What CS area(s) are you interested in?

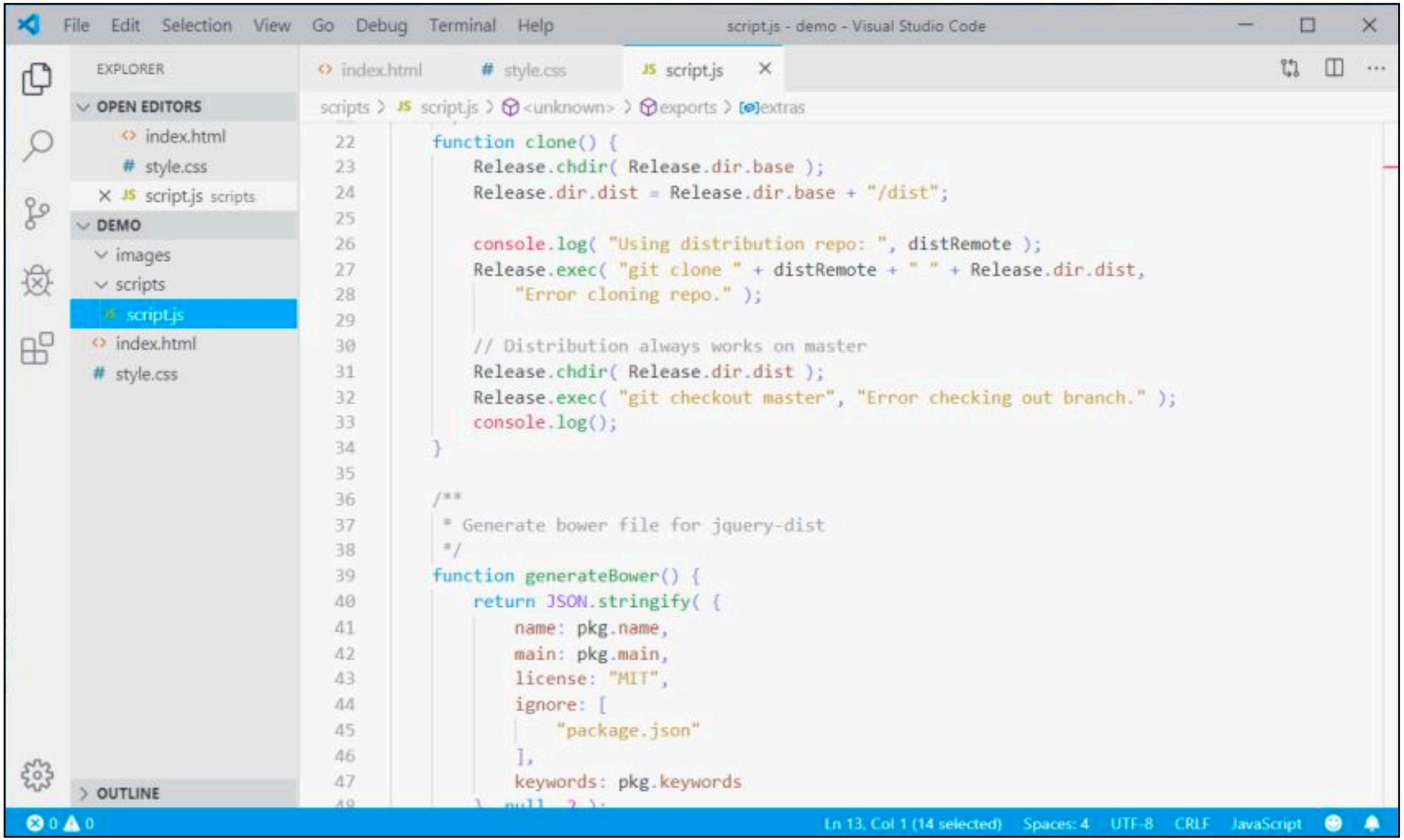
Agenda

- Introduce yourself
- **Course overview**
- Logistics overview

Course Overview

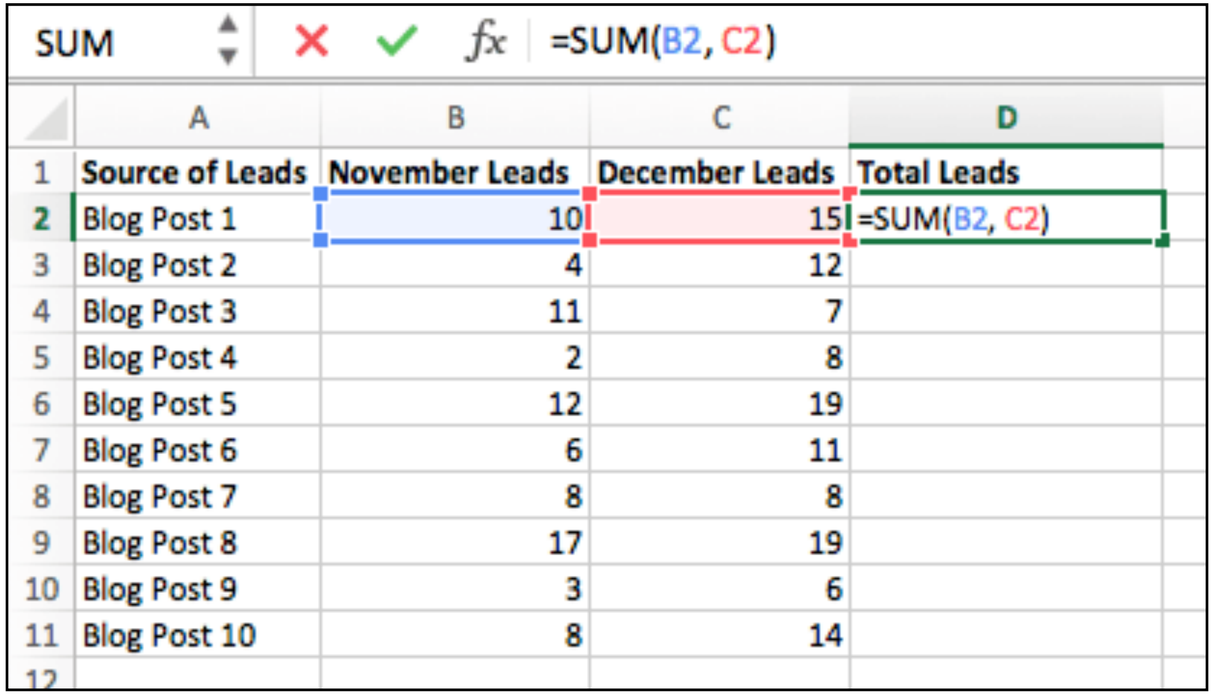
- What's this course about?
  - Intelligent programming systems, powered by program synthesis
  - Make programming systems more intelligent
- What's "programming systems"?
  - Broad: programming languages, compilers, runtime systems, …

E.g., IDEs (VS Code, Eclipse, …)



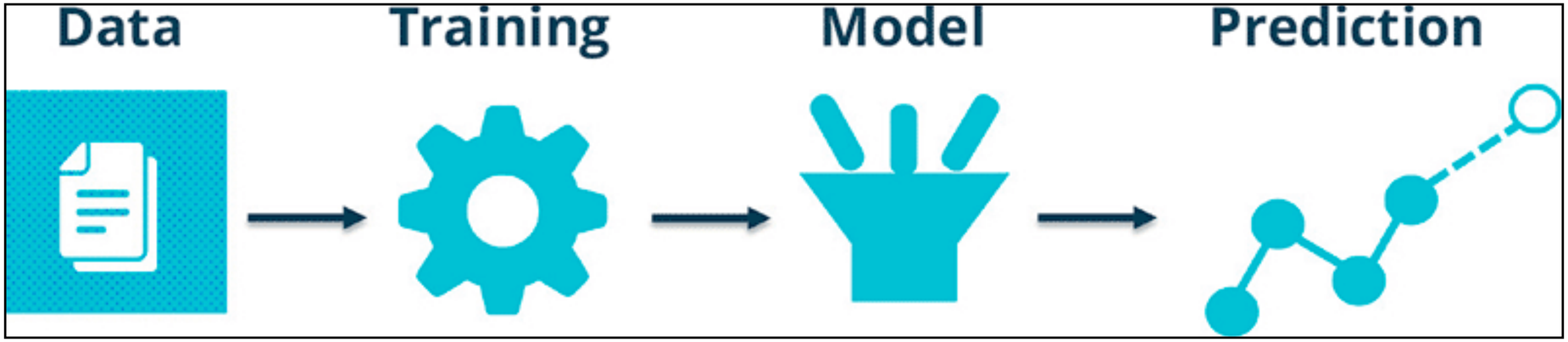
E.g., Compilers (gcc, llvm, …)

E.g., Spreadsheets (Excel, …)



	A	B	C	D
1	**Source of Leads**	**November Leads**	**December Leads**	**Total Leads**
2	Blog Post 1	10	15	=SUM(B2, C2)
3	Blog Post 2	4	12	
4	Blog Post 3	11	7	
5	Blog Post 4	2	8	
6	Blog Post 5	12	19	
7	Blog Post 6	6	11	
8	Blog Post 7	8	8	
9	Blog Post 8	17	19	
10	Blog Post 9	3	6	
11	Blog Post 10	8	14	
12				

E.g., Machine Learning Pipelines



Course Overview

- What's this course about?
  - Intelligent programming systems, powered by program synthesis
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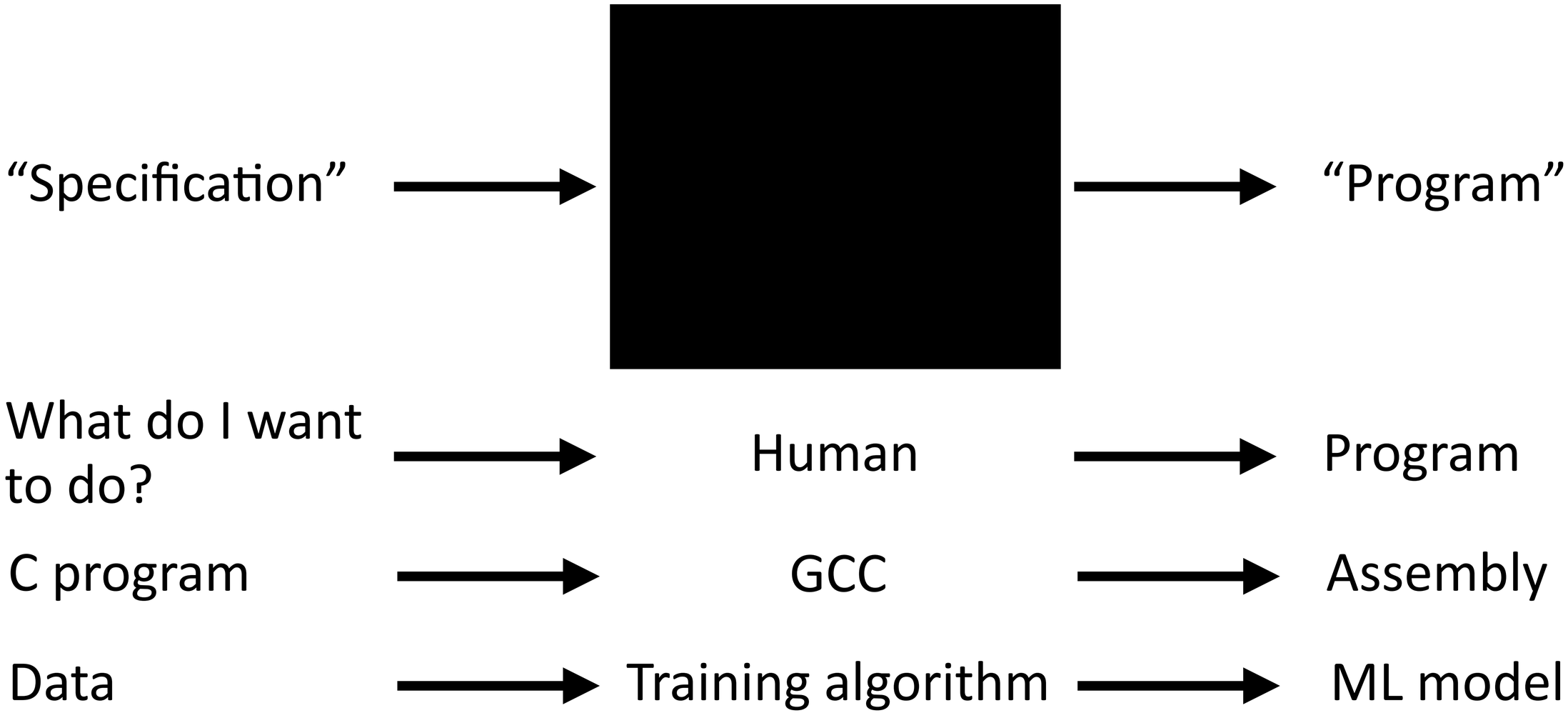
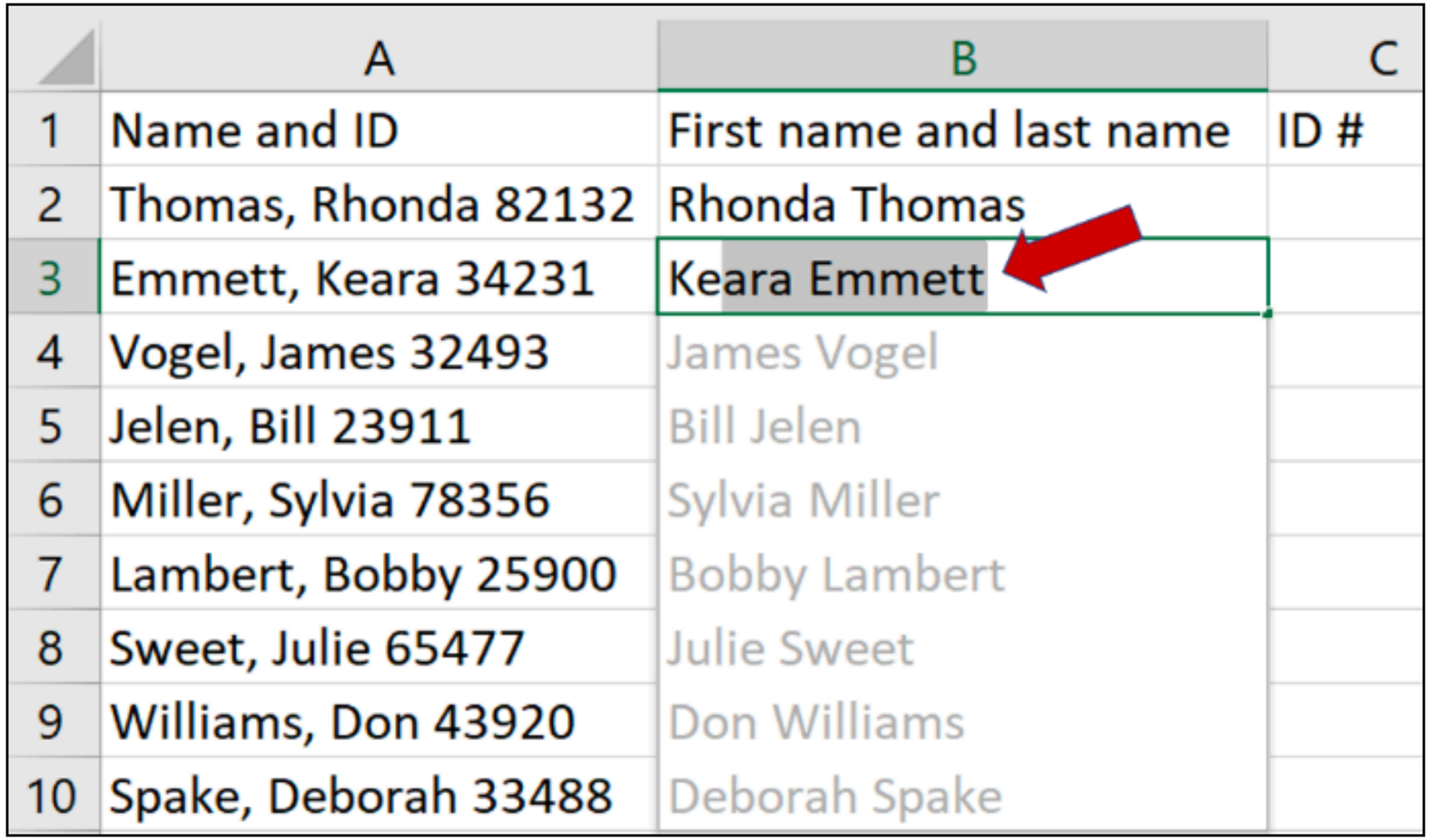
- What's "programming systems"?
  - Broad: programming languages, compilers, runtime systems, …
  - They have to do with programming
  - What's "programming"?

Programming

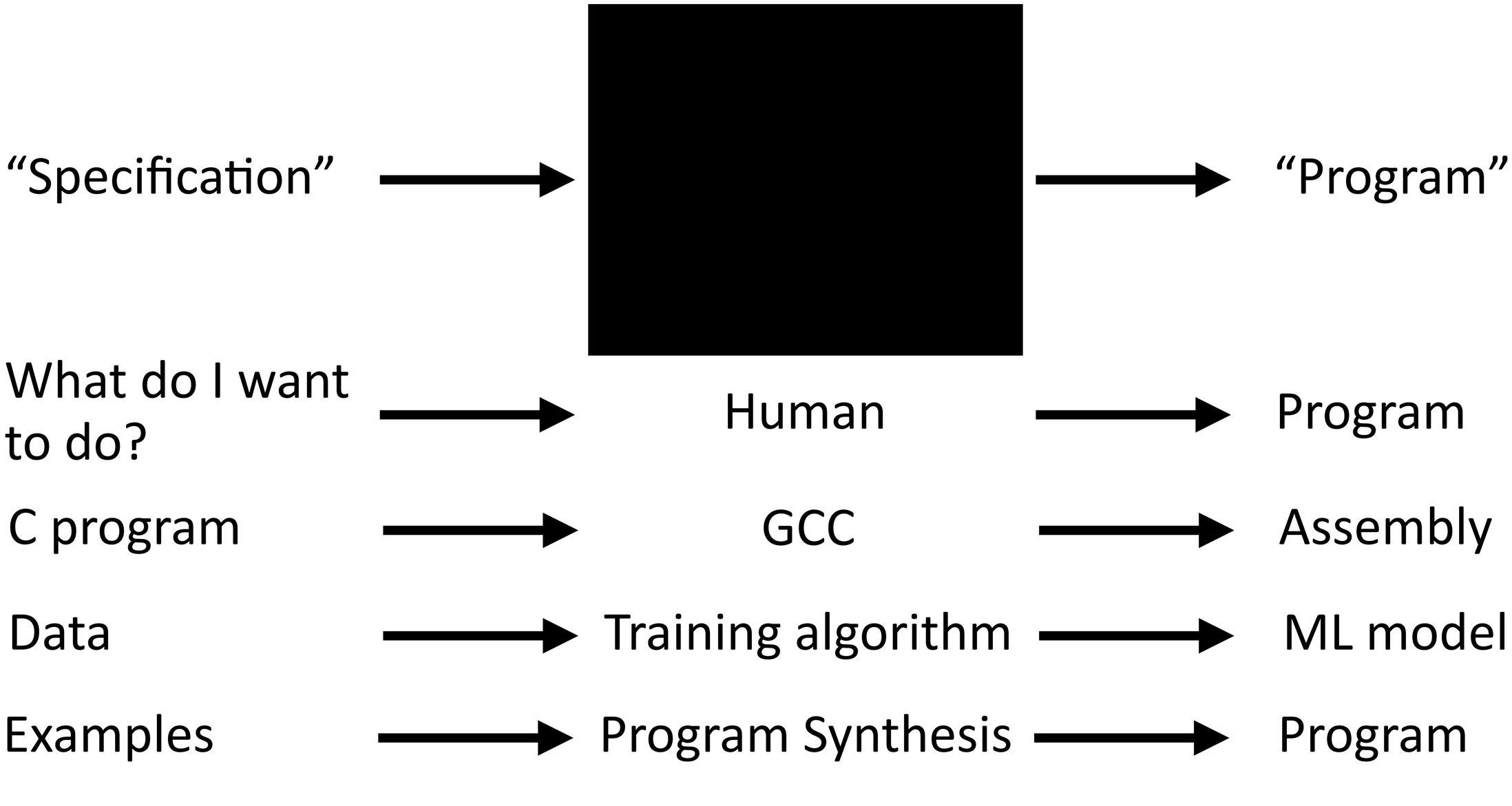


How about this (FlashFill feature in Excel)?



	A	B	C
1	Name and ID	First name and last name	ID #
2	Thomas, Rhonda 82132	Rhonda Thomas	
3	Emmett, Keara 34231	Keara Emmett	
4	Vogel, James 32493	James Vogel	
5	Jelen, Bill 23911	Bill Jelen	
6	Miller, Sylvia 78356	Sylvia Miller	
7	Lambert, Bobby 25900	Bobby Lambert	
8	Sweet, Julie 65477	Julie Sweet	
9	Williams, Don 43920	Don Williams	
10	Spake, Deborah 33488	Deborah Spake	

Programming



Course Overview

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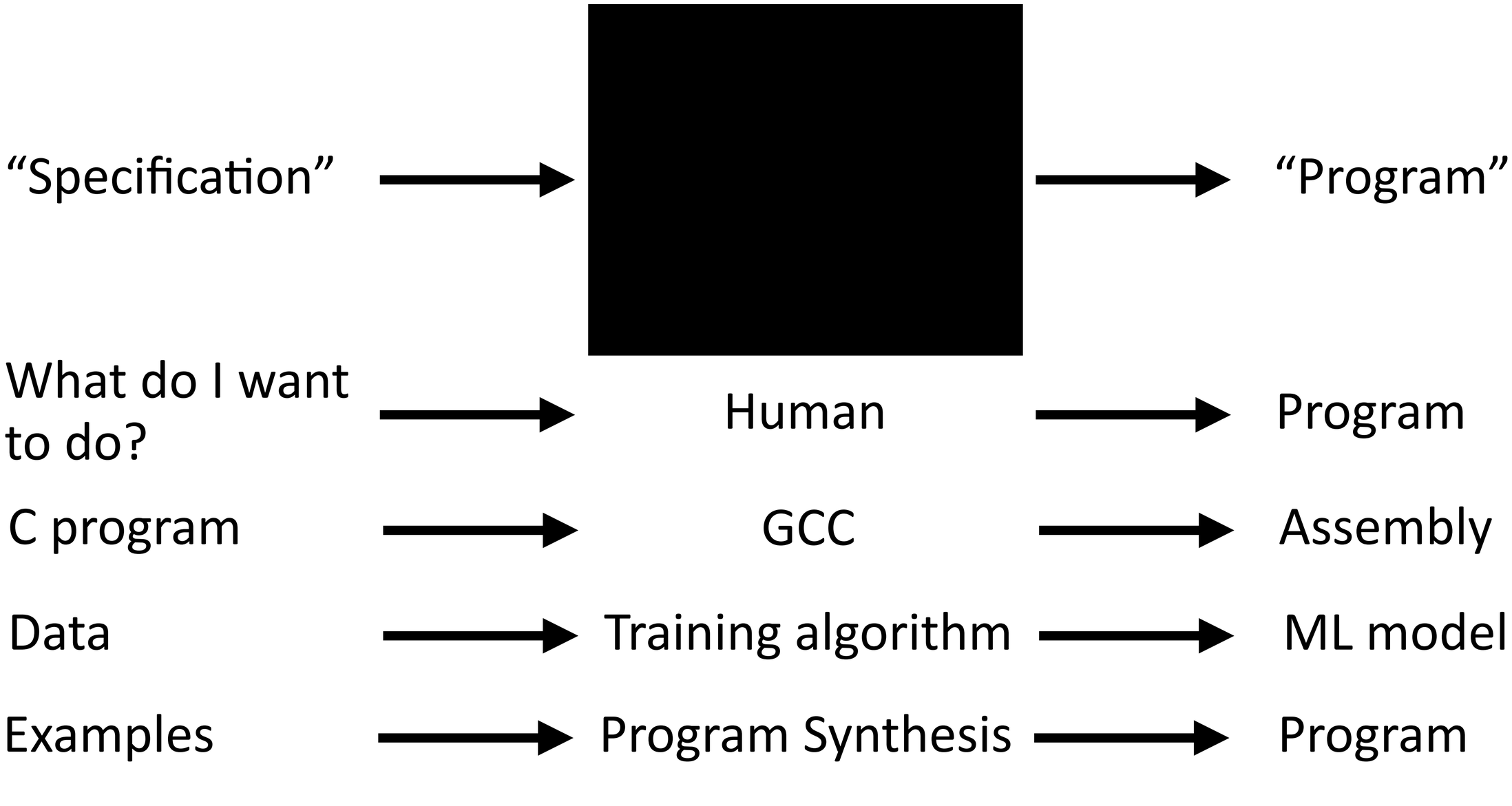
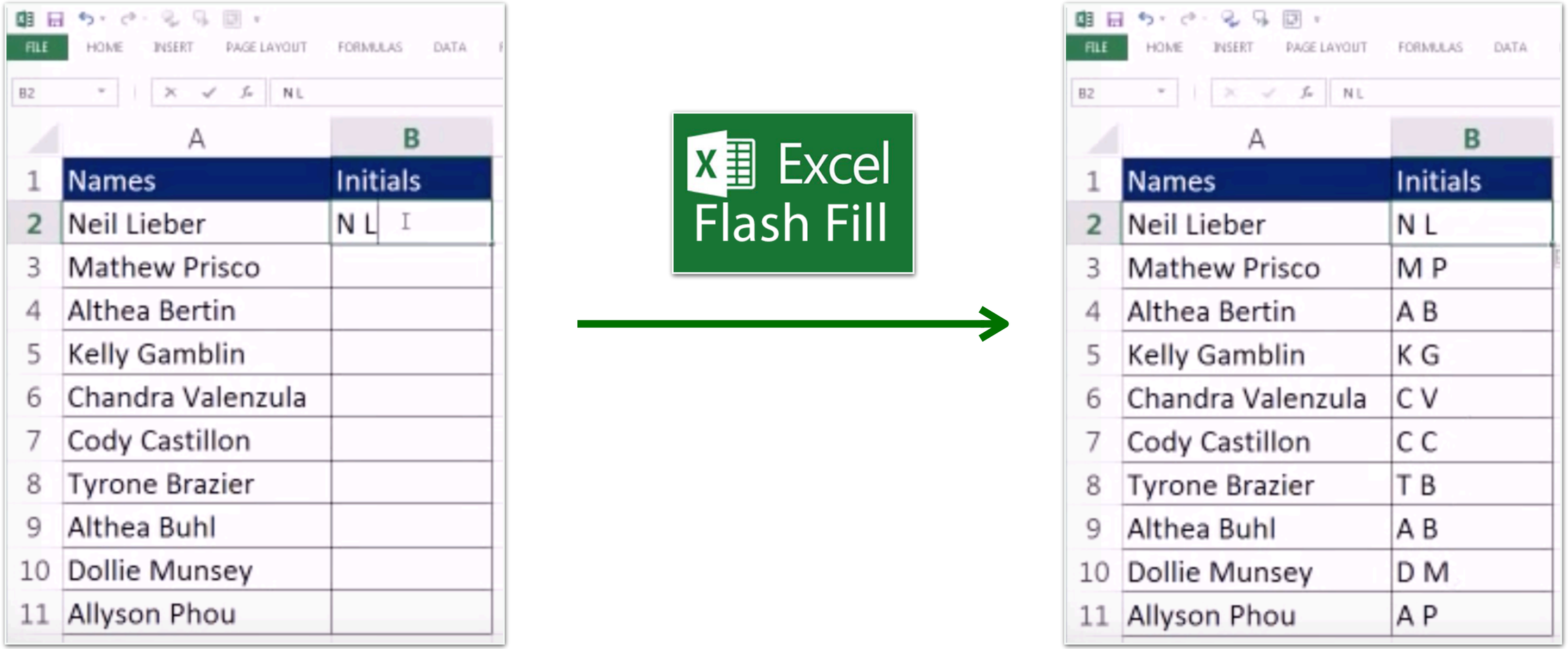
- What's "programming systems"?
  - Broad: programming languages, compilers, runtime systems, …
  - They have to do with programming
  - What's "programming"? Specifications —> Programs
- How to make it more "intelligent"?
  - Specifications: more "high-level"
  - Programming process: more automated

Programming



E.g., FlashFill [Gulwani et al. 11]

- Synthesize Excel macros for string processing from input-output examples (video)

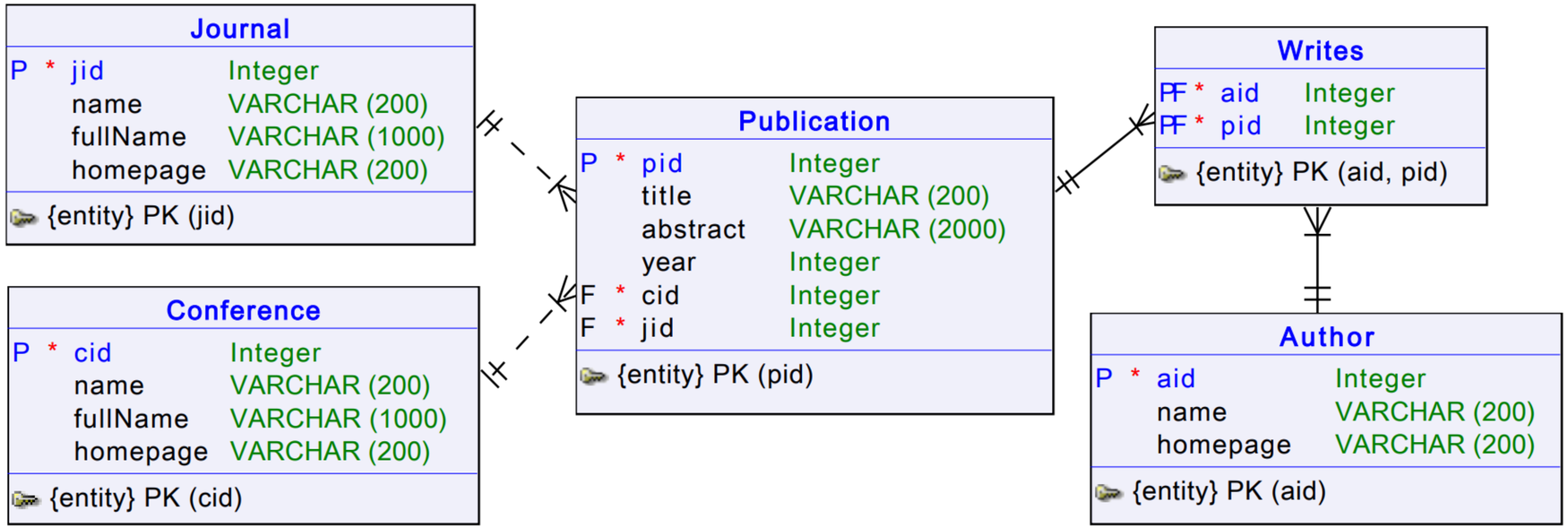


E.g., SQLizer [Yaghmazadeh et al. 17]

- Synthesize SQL queries from natural language (given schema)

NL: *"Find the number of papers in OOPSLA 2010"*

Schema:

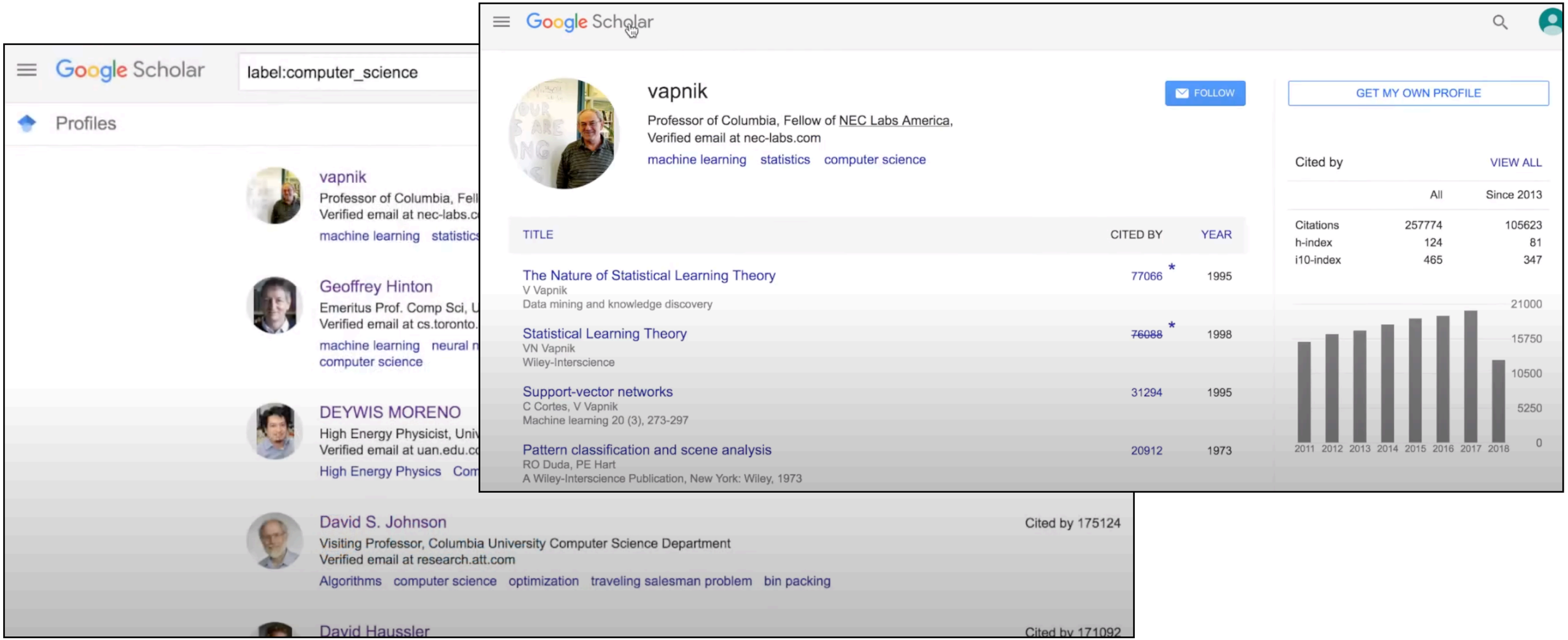


SQL query:

```
SELECT count(Publication.pid)
FROM Publication JOIN Conference ON Publication.cid = Conference.cid
WHERE Conference.name = "OOPSLA" AND Publication.year = 2010
```

E.g., Rousillon [Chasins et al. 18]

- Synthesize web scraping scripts from example demonstrations (video)



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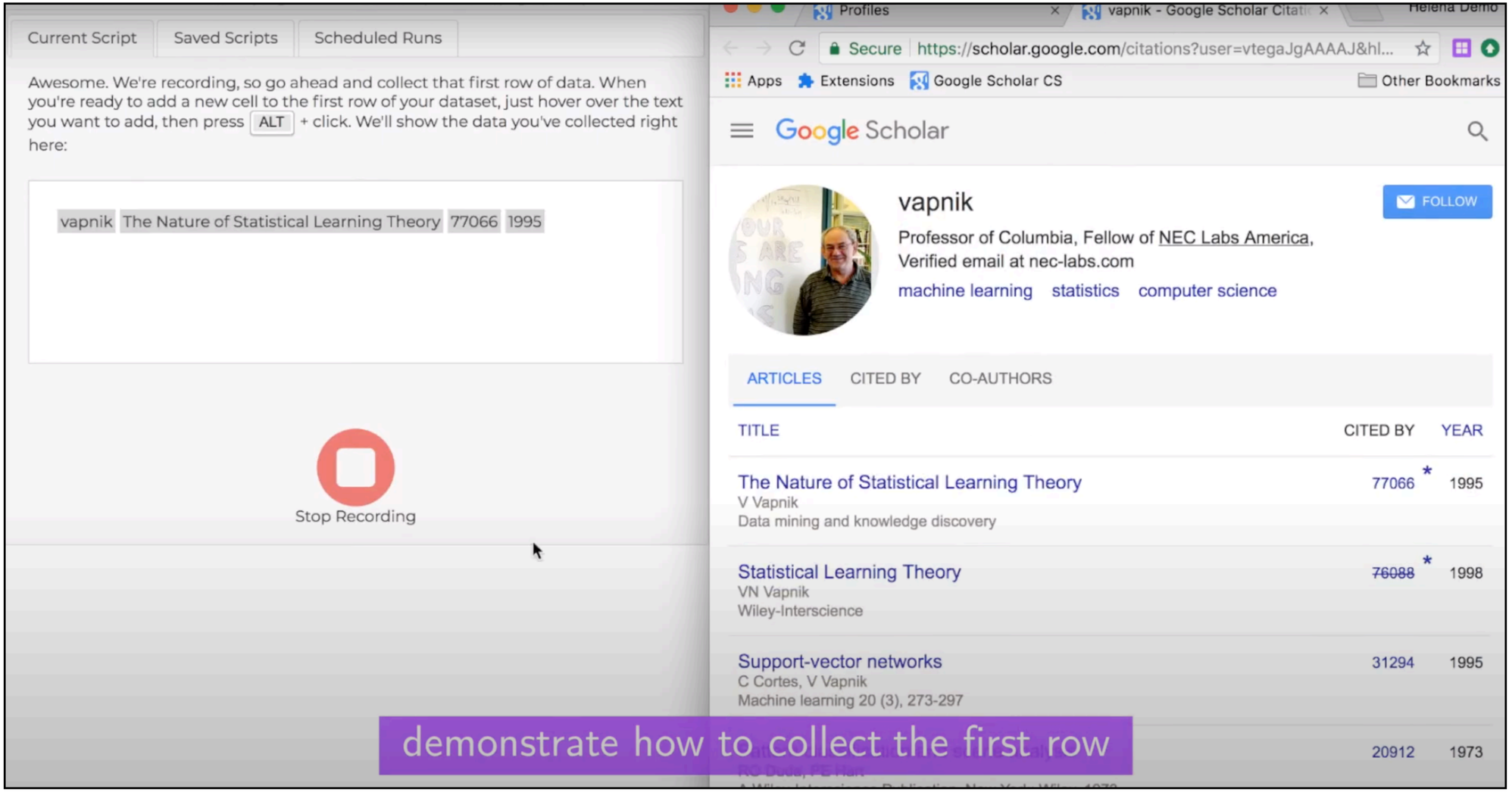

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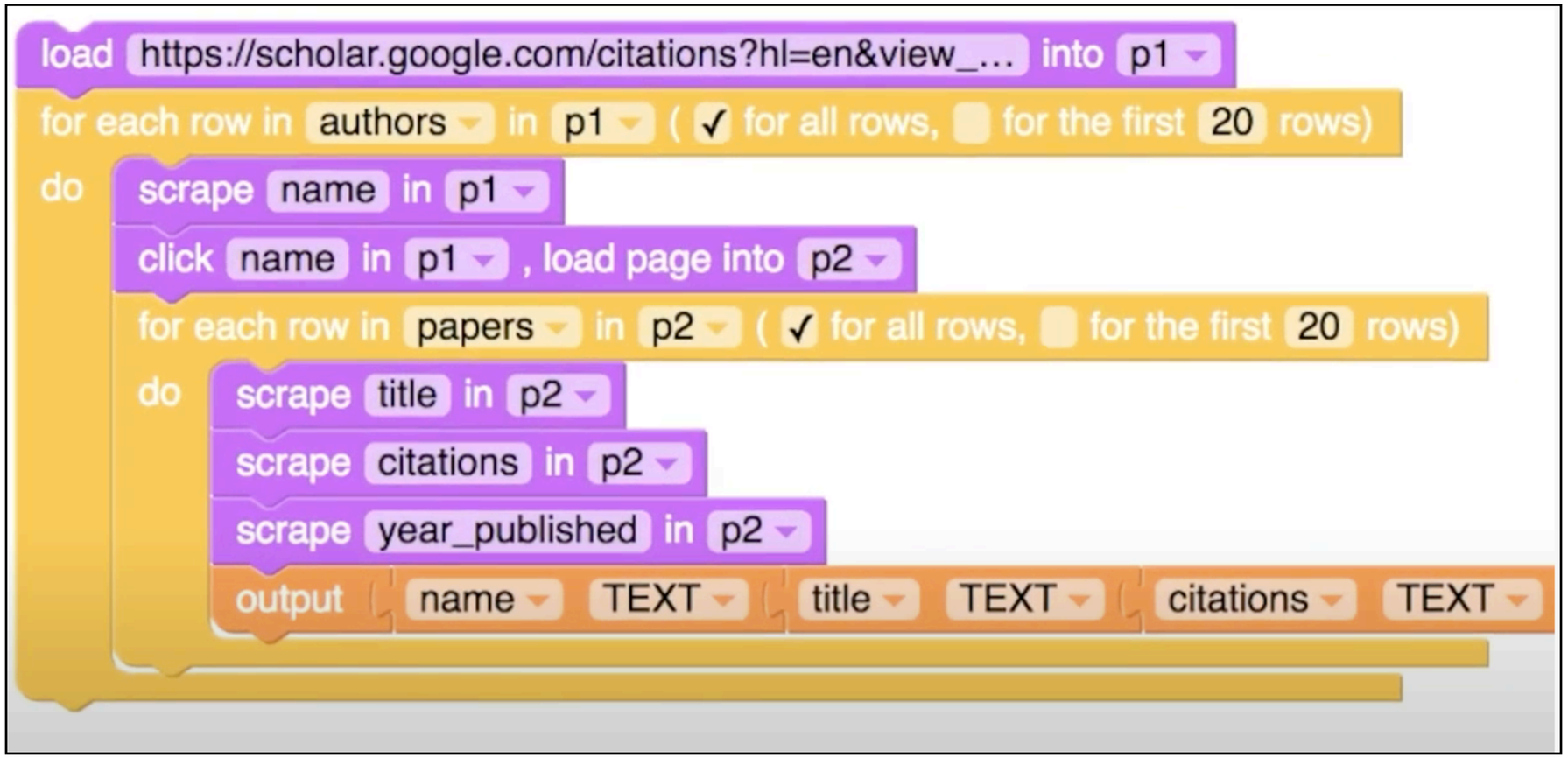

This Course

- How to “automatically” generate “programs” from “specifications”?
  - Program synthesis, in different application domains
- Learn fundamental concepts in programming languages, automated reasoning, formal methods, formal languages, etc.
- Build a real program synthesizer (for R language)
- Read papers on program synthesis
  - How to apply program synthesis to solve interesting problems in many other areas: data science, data wrangling, databases, web automation, etc.
  - How to develop better program synthesis techniques: using HCI, ML, NLP, etc.
- Work on your own project and present it to others

Working Definition of Program Synthesis

High-level intent

Specification

I/O examples, demonstrations, natural language, reference implementation, etc.

Program synthesis

Typically involves search

Lower-level code

Program

In some programming language (grammar + semantics)

Program Synthesis vs. Machine Learning/Deep Learning

- ML/DL is also program synthesis?
  - ML/DL: data is spec, model is program, try to learn a model that matches data
  - At a high-level, yes
  - Not the focus of this course
    - Definitions of “programs” are very different (e.g., grammar vs. neural nets)
    - Data is noisy whereas spec is less noisy (but there is a trend in program synthesis to tolerate noise in spec)
    - Typically continuous in ML/DL vs. discrete search space in program synthesis
    - The line is getting blurry

Program Synthesis vs. Compilers

- Program synthesizers are compilers? Compilers are synthesizers?
  - Compilers also convert high-level intent (code) to lower-level code
  - At a high-level, yes
  - Not the focus of this course
    - Compilers translate (well, not really nowadays) whereas synthesizers discover
    - Compilers apply predefined transformations (again, not really nowadays) whereas synthesizers perform search
    - The line is getting blurry

Working Definition of Program Synthesis

High-level intent

Specification

I/O examples, demonstrations, natural language, reference implementation, etc.

Program synthesis

Typically involves search

Lower-level code

Program

In some programming language (grammar + semantics)

Agenda

- Introduce yourself
- Course overview
- **Logistics overview**

Two Cohorts of Students

- EECS 598 (3 credits): Graduate Students
- EECS 498 (4 credits): Undergraduate Students

Lectures, Discussions, Office Hours

- Lectures: 1010 DOW, 3-4:30pm Tuesdays and Thursdays
  - Learn fundamentals
  - Can attend remotely live via zoom
  - Recordings available afterwards
- Discussions: 3-4pm Fridays, see schedule for details re. location
  - Tutorials of necessary tools, explain assignments, etc.
- Instructor Office Hours: 3-4pm Wednesdays
- GSI Office Hours: 4:30-5:30pm Monday

Schedule

- Weeks 1-6: fundamentals
  - Lectures
  - Assignments
- Weeks 7-14
  - Research papers (reading, reviews, presentations)
  - Final project (proposal, two checkpoints, final project report & presentation)
- Detailed schedule online

What Do You Need To Do?

- Rationale: graduate students should focus on research, undergraduate students should focus on learning fundamentals but also get exposed to research as possible

	EECS 598	**EECS 498**
Class Participation	Yes (10%)	Yes (10%)
Assignments	Optional (15%)	Yes (30%)
Paper Reviews	Yes (20%)	Optional but highly recommended (10%)
Paper Presentations	Yes (25%)	Optional but highly recommended (20%)
Final Project	Yes (50%)	Yes (50%)

Class Participation

- **Try to** attend lectures/presentations/discussions, in person or remote
- Actively participate in **offline** paper discussions
  - Share your ideas/thoughts/comments
  - Ask questions
  - Answer questions

Assignments

- Four programming assignments
  - Progressively build a (simple) program synthesizer for R language
  - **A0 is out today**
- Due dates online

Paper Reviews

- Starting week 7, we will discuss a paper in each lecture
- Write a paper review before lecture
  - Short summary of paper
  - Strengths
  - Weaknesses
  - Questions/thoughts/limitations/etc.
- Submit review via HotCRP by **noon the day before lecture**
- Once you submit your review, you can see other reviews and discuss on HotCRP

Paper Presentations

- A list of papers will be made available online
- Each student will present one paper (likely with a co-presenter)
  - Read the paper (may need to pick up necessary background knowledge)
  - Prepare presentation
    - At least slides, demo if possible
  - Present the paper (45min talk + 30mins Q&A)
    - Thorough, cover background (45m is quite a long time)
    - Give high-level ideas as well as important lower-level technical details
    - Show one concrete example illustrating how everything works

Final Project

- 50% of final grade, very important
- Start early! Call For Proposals out **September 28th**
- Multiple steps
  - Find your teammates (solo okay; typically 2-3; if more than 3, talk to instructor)
  - Proposal
  - Checkpoint 1
  - Checkpoint 2
  - Final Project Presentation
  - Final Project Report

Final Project: Find Your Teammates

- On your own? That’s okay, but consider looking for at least a collaborator!
- Work with 1-2 other students? Great!
- Form a bigger group? Sure, but the project scope will need to be bigger, too.
  - Discuss with the instructor

Final Project: Proposal

- 2-3 page that covers:
  - Statement of the problem you plan to investigate, including:
    - Definition of the problem
    - Concrete examples illustrating the problem
  - Explanation why this problem is interesting and why is it worth solving
    - E.g., how existing techniques are not sufficient in solving this problem
  - Description of your proposed approach
    - Can be a rough idea (proposal is not final report!)
    - Outline of important milestones
  - How to evaluate your proposed approach
    - On what benchmarks do you plan to evaluate your approach?
    - What are the success metrics? How do you know your approach works?

Final Project: Proposal

- What is a good topic for final project?
  - Type 1: Extending an approach from a paper
    - Their solution has certain limitations. Your approach extends their idea.
  - Type 2: Propose new ideas for an old problem
    - Replace (instead of extending) their solution with a better one
  - Type 3: Solve a new problem using standard techniques
    - Apply an existing solution (with tweaks) to a new problem
  - Type 4: new problem, new solution
    - Great!
- **Work on what's most exciting to you!**

Final Project: Two Checkpoints

- “Partial reports”
  - Accomplish important milestones
  - Eventually lead to Final Project Report

Final Project: Final Project Presentation

- Just like a paper presentation, but it's for your "paper"
  - That means, you can just follow how you present other people's work, but this time you're presenting your own work!

Final Project: Final Project Report

- 6-8 pages (in ACM's double-column conference format)
  - Introduction: what problem you're solving and why it's important (1 page)
  - Motivating example: use one concrete example to illustrate the problem as well as your solution (1-2 pages)
  - Your approach: explain in detail how your approach works (2-3 pages)
  - Evaluation: how you evaluate your approach, what the results are, and why they are what they are (1-2 pages)
  - Related work: how your work differs from prior work (1 page)

What Is This Course About?

- This course is about program synthesis, including both techniques and applications
  - Techniques: general synthesis algorithms not necessarily tied to a specific application
  - Applications: novel application of program synthesis techniques

- Beyond acquiring knowledge about program synthesis, also:
  - PL/formal thinking
  - Practice other skills: writing, presentation, etc.
  - Get exposed to research: through reading papers, doing a mini research project

Why This Course?

- Very hot research topic at the interaction of AI/ML and Systems/PL
- Useful in practice, e.g., FlashFill in Excel
- Technically very challenging
  - Essentially, a very hard search problem

- .. if you plan to explore possibilities of applying PL in your own research
- .. if you plan to pursue research career in PL/Formal Methods
- .. if you are interested in programming languages research
- .. if you just want to learn about the topic!

Survey (optional)

- Send me a brief email with:
  - Name
  - I am a [CS/__] [PhD/Masters/undergrad] in year [1/2/3/4/5/…]
  - Write one reason why you are taking this class or one thing you want to get out of it
  - One thing you would like the instructor to do in this class
  - One fun fact about you, or what you like to do in your spare time, or whatever