GI++ == Focused Auto Programming?

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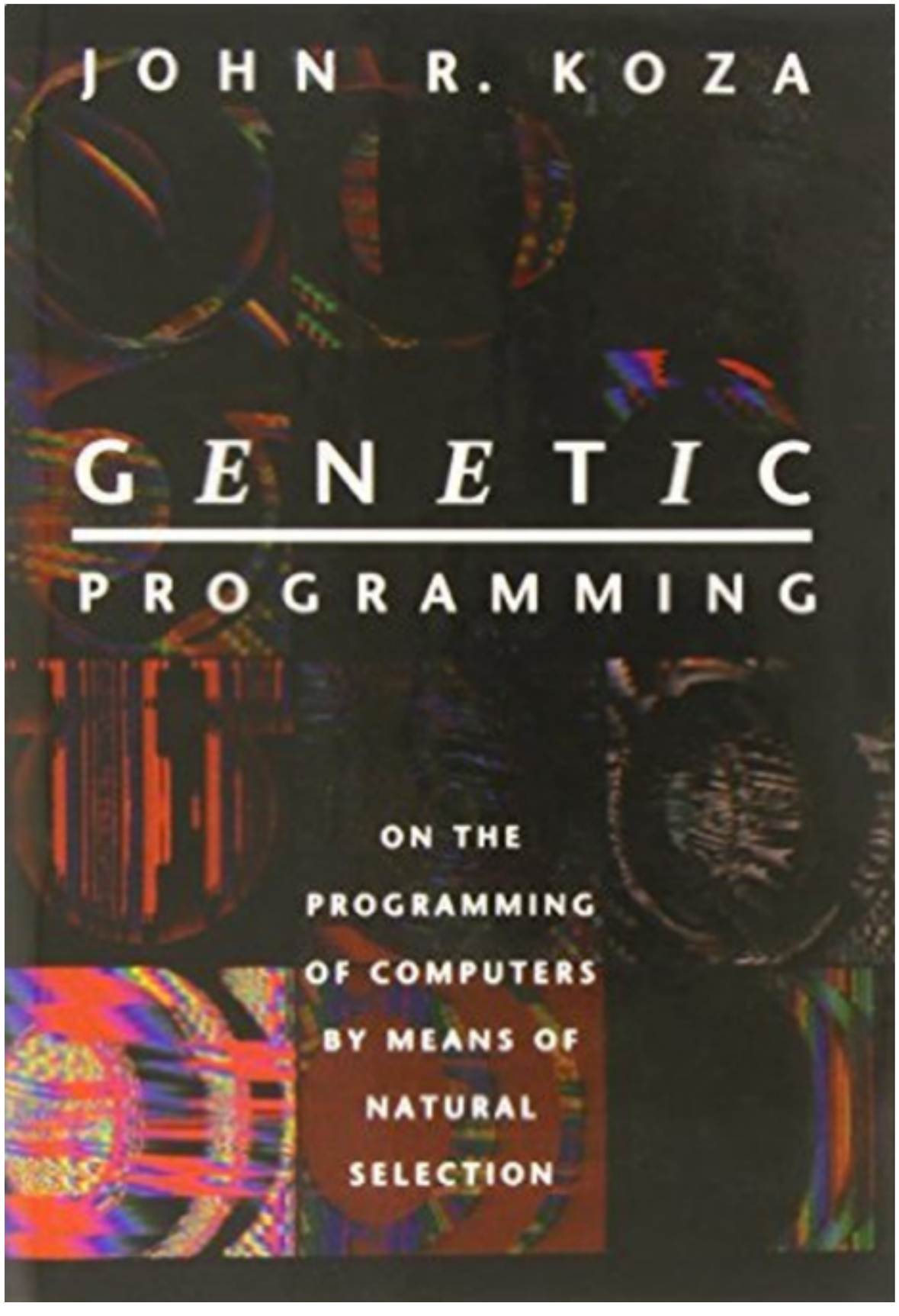
One view of SBSE: Ever-expanding Success!

A contrarian view of SBSE: Not quite there yet…



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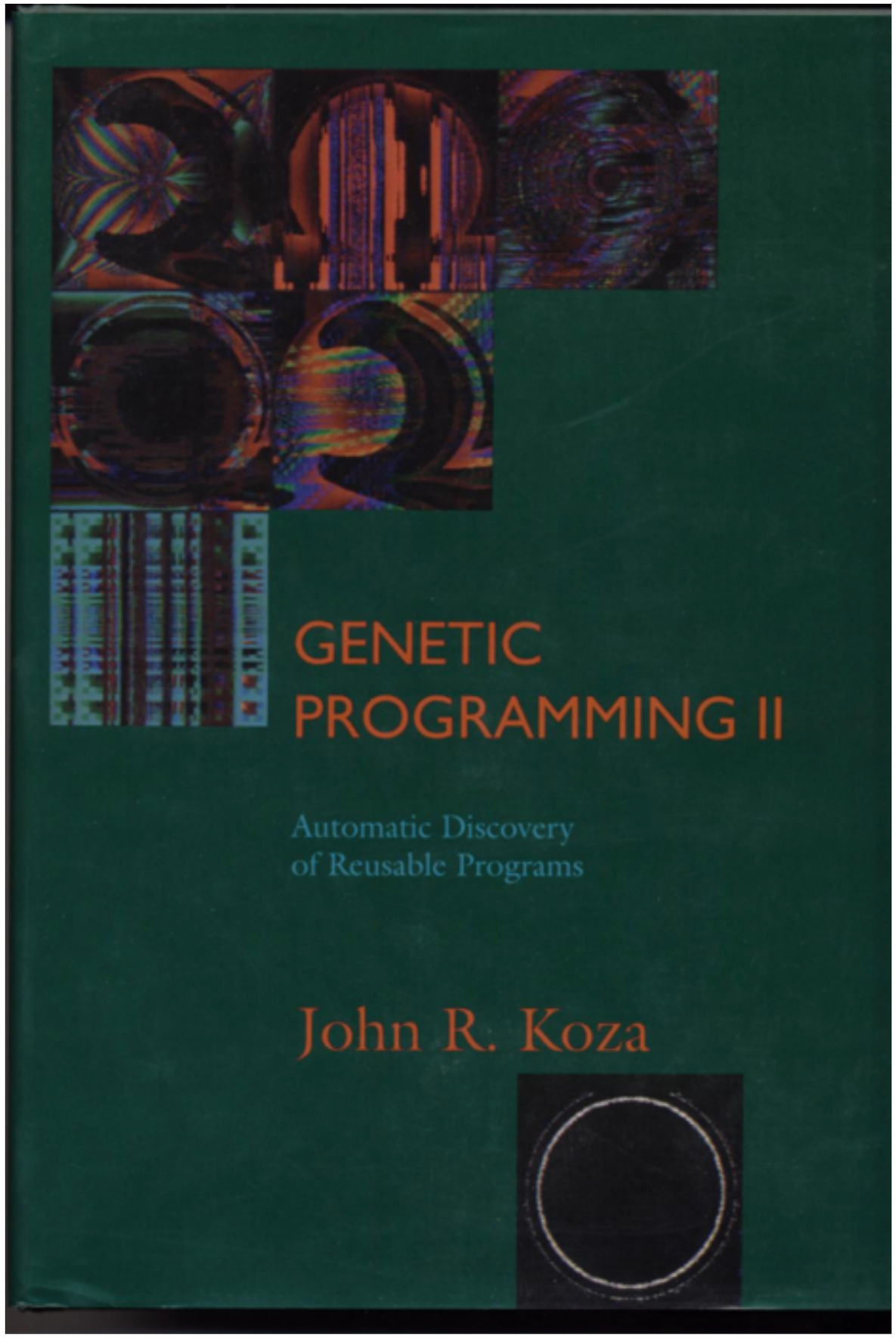

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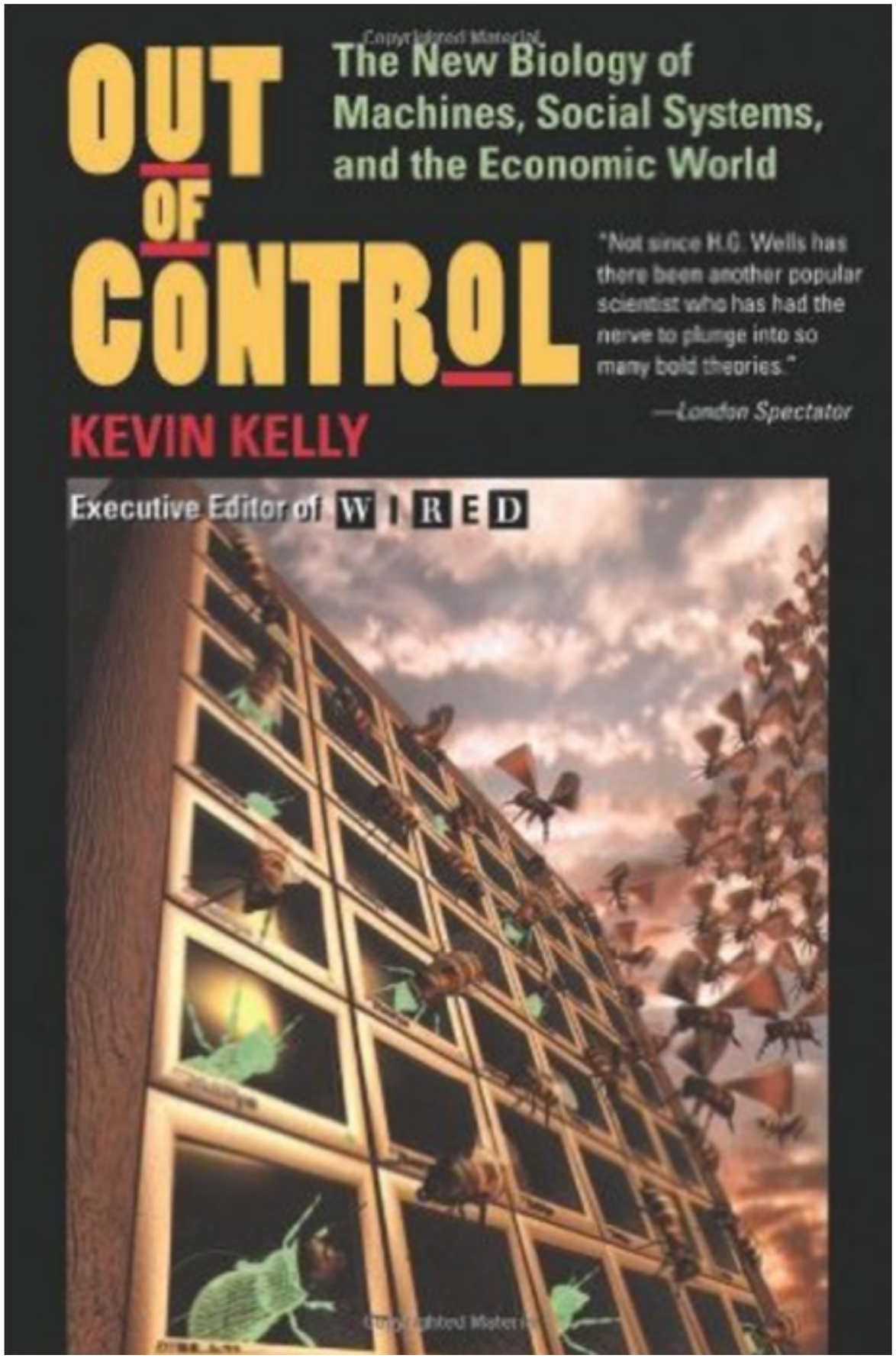

"Evolution is the natural way to program. I would rather fly on a plane running software evolved by a program like this, than fly on a plane running software I wrote myself," says Hillis, programmer extraordinaire.

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Of course it all started much earlier (with Turing)… ;)

In his 1950 paper "Computing Machinery and Intelligence," Turing described how evolution and natural selection might be used to automatically create an intelligent computer program [2].

"We cannot expect to find a good child-machine at the first attempt. One must experiment with teaching one such machine and see how well it learns. One can then try another and see if it is better or worse. There is an obvious connection between this process and evolution, by the identifications
"Structure of the child machine = Hereditary material"
"Changes of the child machine = Mutations"
"Natural selection = Judgment of the experimenter"

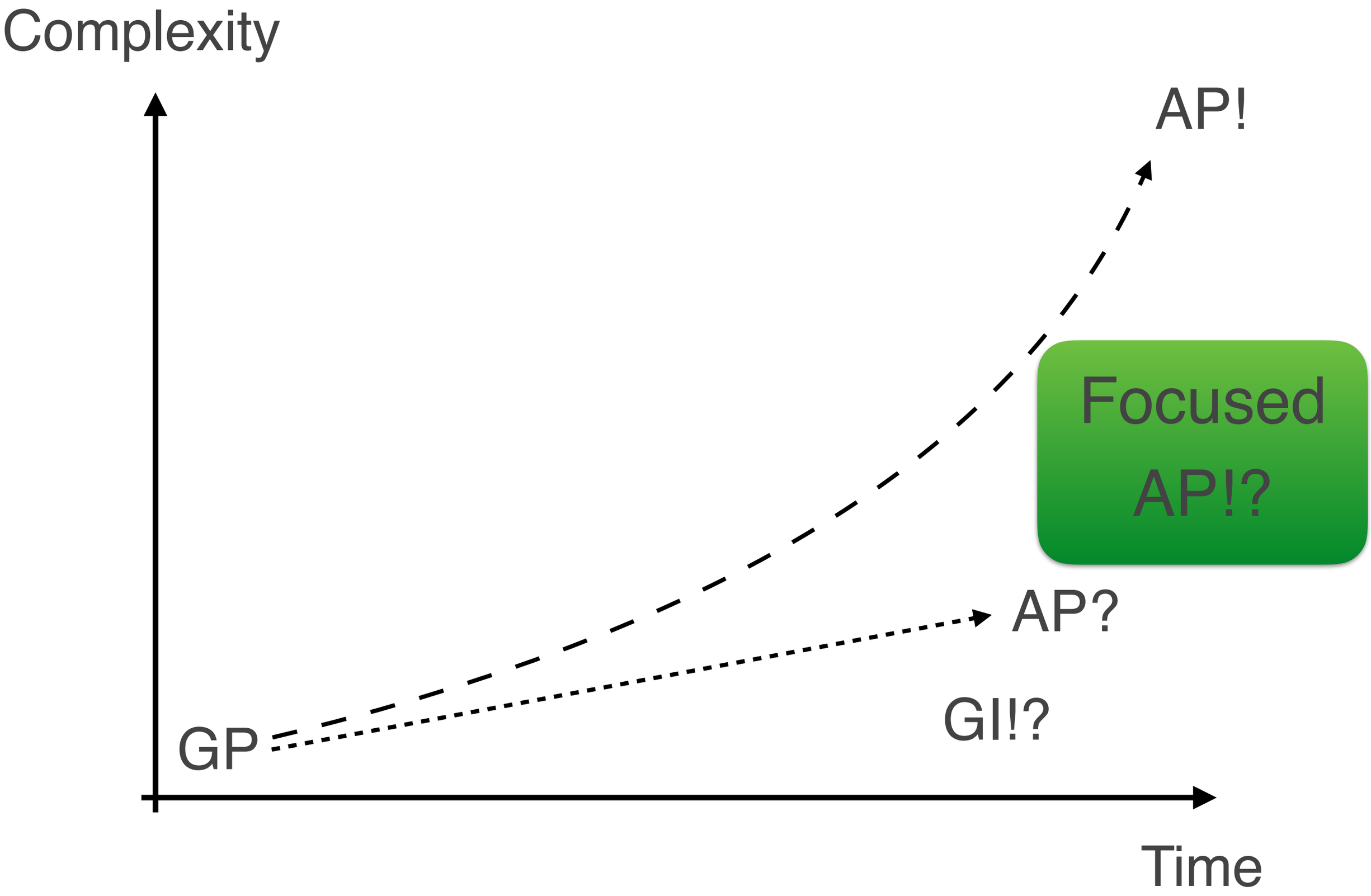
[Koza2010] in GPEM Anniversary issue

Some common GP/SBSE "cop outs"

- Tune only constants/numbers in fixed program
- Delete/remix existing code
- Focus on (minimal) interfaces between existing codes
- Focus on non-mainstream/obscure languages / processing formalisms where humans (currently) have less experience
- Evolve test data rather than programs
- Evolve test cases and not programs
- Requiring lots and lots of example Input/Outputs
- …

Clear goal, small search space, less/short structure

A continuum of Automated Programming



Focused Automated Programming

- I propose we should study FAP! aka…
  - Domain-specific Automated Programming (DAP)
  - Task-specific Automated Programming (TAP)
- Defined as: *“Focused application of search and optimisation to create/adapt/tune (parts of) program code during its development, setup and/or execution”*
- Focused here essentially means “human-guided”, i.e. it is a hybrid/interactive development philosophy
- => we need ideas, intuition and methods/processes for how to use search/optimisation more actively in the software development process

Example: Web extraction library

V Basili

Professor Emeritus University of Maryland
Software Engineering
Verified email at cs.umd.edu - Homepage

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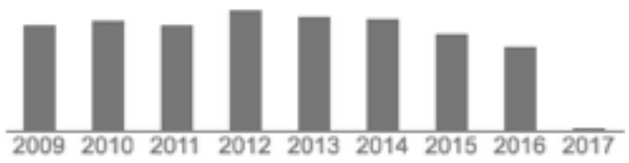
Title 1–20	Cited by	Year
Experience factory VR Basili, G Caldiera, HD Rombach Encyclopedia of software engineering	3557	1994
A validation of object-oriented design metrics as quality indicators VR Basili, LC Briand, WL Melo	1755	1996

Google Scholar

Citation indices	All	Since 2012
Citations	33501	9054
h-index	82	41
i10-index	248	123



```
{
   “name”: “V Basili”,
   “citations”: 33501,
   “h-index”: 82
}
```

Web extraction, traditional solution vs AdaptiLib

WebGet Lib + XML Parser Lib + Custom code

Regex Lib

AWE Lib + Examples

Adaptive Libraries

- A normal library (lib):
  - 1. has a number of functions that can be called
  - 2. to solve specific tasks
  - 3. has documentation to describe the functions
  - 4. and examples to understand API & how to put together
- But only 1 above is directly useable without a human
  - 2-4 requires a human to assemble solution based on text
- Adaptive libraries (AdaptiLibs):
  - 1. Still has basic “atoms” = functions to be called
  - (2a) But also executable examples that uses atoms to perform specific, named sequences
  - (2b) And allow fuzzy mapping of user needs to tasks

Example: Adaptive Web Extraction (AWE!) library, in practice

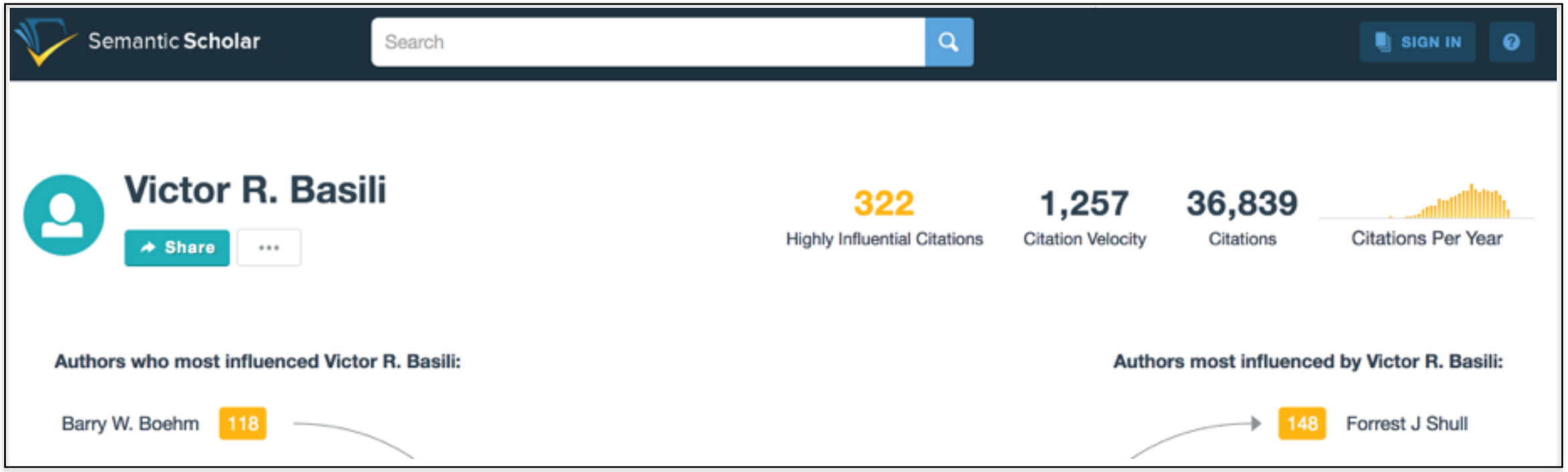
```
examples = [
(“scholar.google.se/citations?user=B3C4aY8AAAAJ&hl=en”,
{“name”: “V Basili”,
   “citations”: 33501,
   “h-index”: 82}),
(“scholar.google.se/citations?user=Zj897NoAAAAJ&hl=en”,
{“name”: “Lionel Briand”,
   “citations”: 21505,
   “h-index”: 69})]

gscholar_ex = create_extractor(examples)

extract(gscholar_ex, “scholar.google.se/citations?
user=CQDOm2gAAAAJ&hl=en”)

# returns:
# {“name”: “Barbara Ann Kitchenham”,
#  “citations”: 63,
#  “h-index”: 154})]
```

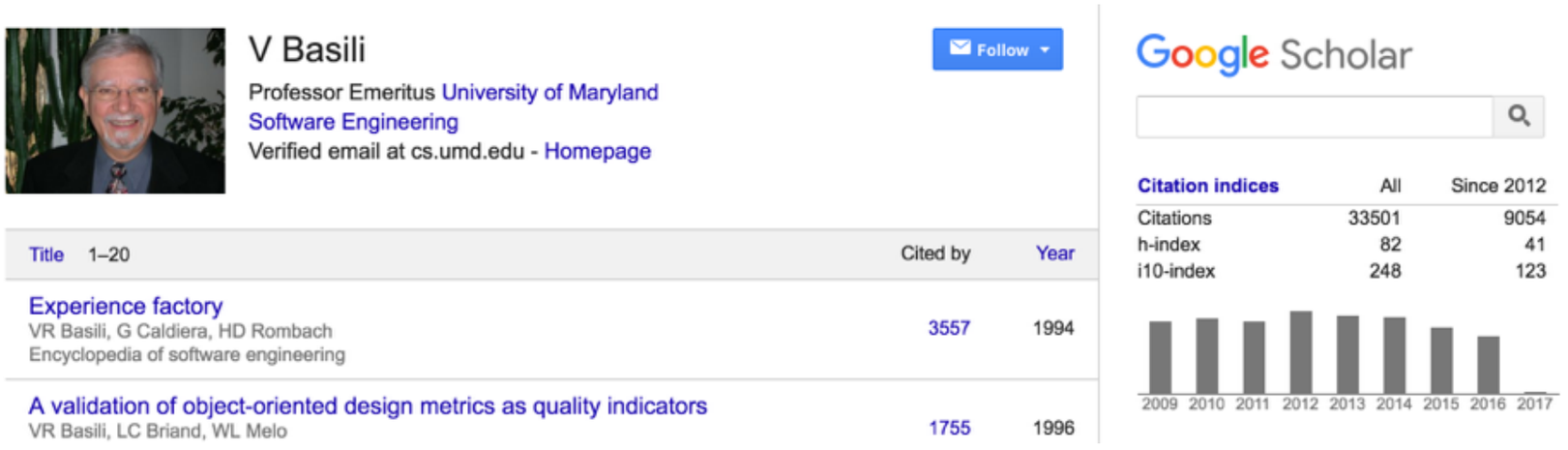
Big benefits with semantically similar task



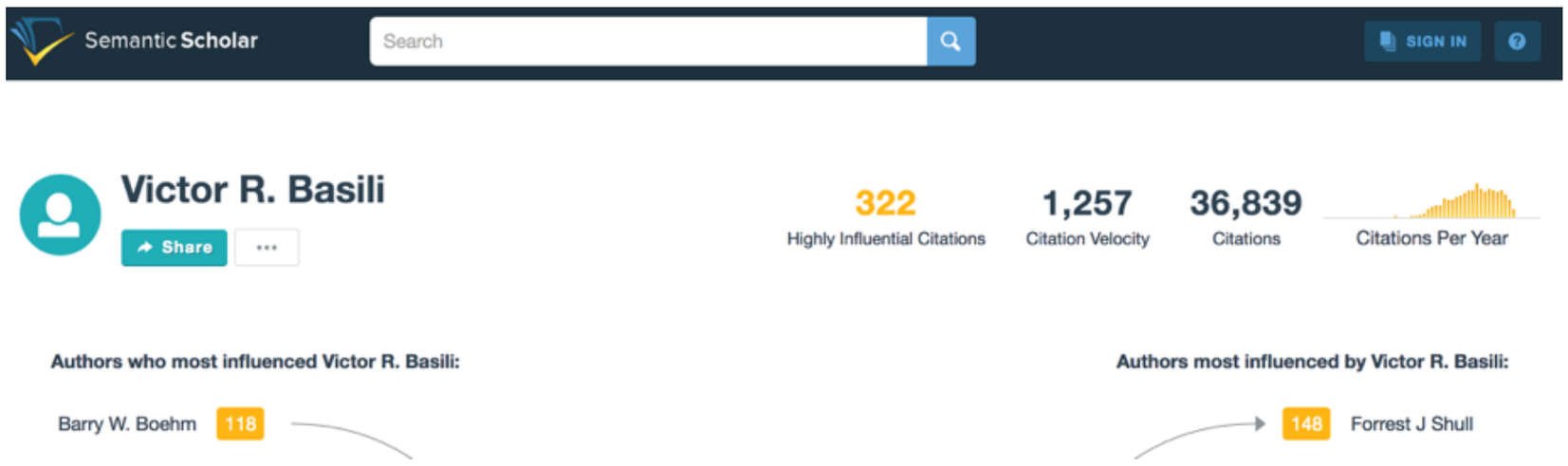

```
{
{  “name”: “Victor R. Basili”,
   “name”: “V Basili”,
   “citations”: 36839,
   “influential”: 3501,
   “h-index”: 82
}
}
```

Only change 2 I/O examples & re-adapt!

GI would not help: Only semantic, not syntactic similarity



"...>Citations</td><td class="gsc_rsb_std">**33501**</td><td class="gsc_rsb_std">9054</td>..."



"...:{"hIndex":51,"estimatedTotalCitationCount":{"min":31675,"value":**36839**,"max":42905,..."

Design Rules for AdaptiLibs (so far…)

- Start by defining basic “atomic” operations
  - Type conversion operations: parseToInt, parseToFloat
  - Data transformation: uppercase, lowercase, leadingcase
  - Basic data access: get_url
  - Matching: matchregexp, matchregexp_ignorecase
- Go through concrete task from example & note how a human solves it in as atomic steps as possible
  - Extend with atoms, and possibly (complex) atom seq.
- Feldt’s Law for Designing Lib incl. Search, consider in order:
  - 1. Deterministic / Exact (fastest, most efficient)
  - 2. Heuristics / Approximations (order by applicability)
  - 3. Focused Search (part of solution only, then aggregate)
  - 4. Interact / Ask Developer (in adapt step)
  - 5. Full/free search (search from atoms & up, warn dev)

Conclusions

- Despite many promises of GP & SBSE it has under delivered on practical Automated Programming
  - Compared to other SBSE, GI comes closer to AP
- As techniques and processing power increase we will see more practical AP
  - But semantic similarity does not imply syntactic similarity
    => less opportunity for detailed code reuse
- But we can also deliver practical AP now by hybridising it with human intelligence and guidance
- We are developing AdaptiLibs, general libraries that adapt to I/O examples of users/developers
  - Combines task-driven design & experience of humans
  - with brute force and flexibility of search, only wh. needed

Thank you!

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But what about Bartoli et al?!

TABLE 1
Results and Salient Information about the Extraction Tasks

						On E			On E^*		
Extraction task E_0	$\lvert E_0\rvert$	$\sum_{E_0} \ell(s)$	$\sum_{E_0} \lvert X_s\rvert$	$\sum_{E} \lvert X_s\rvert$	LR	Fm	Prec	Rec	Fm	EC	TtL
ReLIE-Web/All-URL	3,877	4,240	502	24	5.0	99.2	90.0	91.9	90.9	2.6	15
				50	10.0	99.2	92.1	95.0	93.5	6.4	35
				100	19.9	98.9	94.8	96.5	95.6	13.7	71
ReLIE-Web/HTTP-URL	3,877	4,240	499	24	5.0	99.2	86.3	89.0	87.6	2.5	11
				50	10.0	99.0	91.0	93.3	92.2	5.8	32
				100	20.0	98.8	92.9	96.8	94.8	13.1	66
ReLIE-Email/Phone-Number	41,832	8,805	5,184	24	0.5	97.7	37.1	92.6	48.3	3.4	8
				50	1.0	99.0	29.9	96.6	43.3	6.0	16
				100	1.9	98.9	22.7	98.3	35.8	14.4	39
Cetinkaya-HTML/href	3,425	154	214	24	11.7	100.0	98.7	99.2	98.9	2.5	12
				50	23.4	100.0	98.1	98.7	98.4	4.9	26
				100	46.7	99.8	98.4	99.1	98.8	9.0	59
Cetinkaya-HTML/href-Content*	3,425	154	214	24	11.7	98.4	74.9	98.7	80.6	2.4	16
				50	23.4	98.5	85.1	98.8	88.2	4.8	29
				100	46.7	98.5	83.2	96.8	86.2	10.5	67
Cetinkaya-Web/All-URL	1,234	39	168	24	14.9	99.2	99.4	98.8	99.1	1.7	3
				50	29.8	100.0	95.5	98.6	96.9	3.2	8
				100	59.5	99.5	98.8	98.8	98.8	5.2	16
Twitter/Hashtag+Citation	50,000	4,344	56,994	24	0.1	100.0	98.8	100.0	99.4	1.2	3
				50	0.1	99.6	99.2	100.0	99.6	2.2	4
				100	0.2	99.8	99.0	100.0	99.5	4.6	7
Twitter/All-URL	50,000	4,344	14,628	24	0.2	100.0	94.7	98.5	96.6	1.8	3
				50	0.3	100.0	96.2	98.3	97.2	3.4	8
				100	0.7	99.4	96.1	98.0	97.0	7.7	16
Twitter/Username*	50,000	4,344	42,352	24	0.1	100.0	99.3	100.0	99.7	1.2	2
				50	0.1	100.0	99.2	100.0	99.6	2.2	2
				100	0.2	99.9	99.3	100.0	99.7	4.6	2