Will software developers soon be replaced by AI?
The sense and nonsense of Artificial Programming

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NOKIA Bell Labs

Artificial Programming

- Key idea: given a specification, generate a program that satisfies it

Artificial Programming

- Key idea: given a specification, generate a program that satisfies it
- Example: sorting a list of numbers

```
alist = [54, 26, 44, 17, 77, 31, 91, 56, 20]
sort(alist)

print(alist)
# prints [17, 20, 26, 31, 44, 54, 56, 77, 91]
```

Artificial Programming

- Key idea: given a specification, generate a program that satisfies it
- Example: sorting a list of numbers

```
def sort(alist):
   for index in range(1, len(alist)):
     val = alist[index]
     position = index
     while position > 0 and alist[position-1] > val:
         alist[position] = alist[position-1]
         position -= 1

     alist[position] = val
```

What is a specification?

- **Example: sorting a list of numbers**

Logic

$\forall 1 \leq i < n: B[i] \leq B[i+1] \wedge$
$\exists \sigma,$ a permutation of $[1::n]$, such that
$\forall 1 \leq i < n: B[i] = A[\sigma(i)]$

(source: S. Gulwani, Programming By Examples, 2016)

Examples

Input	Output
[1,3,2]	[1,2,3]
[3,2]	[2,3]
[1,2,3]	[1,2,3]
[]	[]

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Programming by Example: Flash Fill (Gulwani, 2011)

	A	B
1	Email	Column 2
2	Nancy.FreeHafer@fourthcoffee.com	nancy freehafer
3	Andrew.Cencici@northwindtraders.com	andrew cencici
4	Jan.Kotas@litwareinc.com	jan kotas
5	Mariya.Sergienko@gradicdesigninstitute.com	mariya sergienko
6	Steven.Thorpe@northwindtraders.com	steven thorpe
7	Michael.Neipper@northwindtraders.com	michael neipper
8	Robert.Zare@northwindtraders.com	robert zare
9	Laura.Giussani@adventure-works.com	laura giussani
10	Anne.HL@northwindtraders.com	anne hl
11	Alexander.David@contoso.com	alexander david
12	Kim.Shane@northwindtraders.com	kim shane
13	Manish.Chopra@northwindtraders.com	manish chopra
14	Gerwald.Oberleitner@northwindtraders.com	gerwald oberleitner
15	Amr.Zaki@northwindtraders.com	amr zaki
16	Yvonne.McKay@northwindtraders.com	yvonne mckay
17	Amanda.Pinto@northwindtraders.com	amanda pinto

(source: Gulwani et al, “Inductive programming meets the real world”, *Commun. ACM*, 2015)

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8	Robert.Zare@northwindtraders.com	robert zare
9	Laura.Giussani@adventure-works.com	laura giussani
10	Anne.HL@northwindtraders.com	anne hl
11	Alexander.David@contoso.com	alexander david
12	Kim.Shane@northwindtraders.com	kim shane
13	Manish.Chopra@northwindtraders.com	manish chopra
14	Gerwald.Oberleitner@northwindtraders.com	gerwald oberleitner
15	Amr.Zaki@northwindtraders.com	amr zaki
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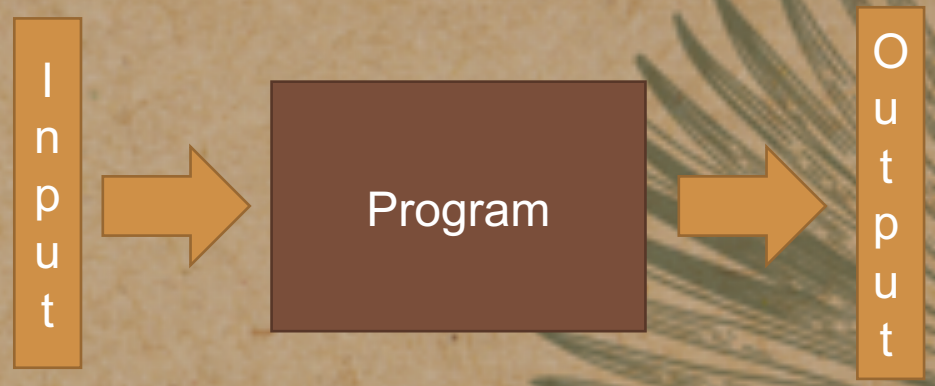

(source: Gulwani et al, “Inductive programming meets the real world”, *Commun. ACM*, 2015)

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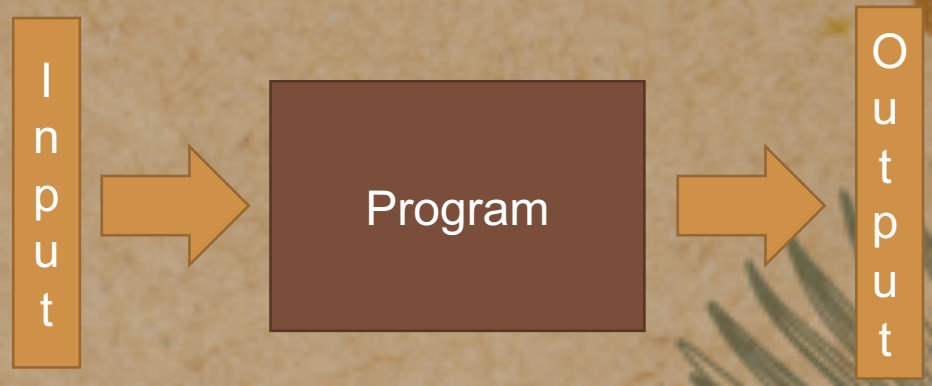
Programming by Example: Flash Fill (Gulwani, 2011)

The Flash Fill Domain-specific Language

$$
\begin{array}{rcl}
\text{String expr } P & := & \texttt{Switch}((\mathrm{b}_1, \mathrm{e}_1), \cdot\cdot, (\mathrm{b}_n, \mathrm{e}_n)) \\
\text{Bool b} & := & \mathrm{d}_1 \vee \cdot\cdot \vee \mathrm{d}_n \\
\text{Conjunct d} & := & \pi_1 \wedge \cdot\cdot \wedge \pi_n \\
\text{Predicate } \pi & := & \texttt{Match}(v_i, \mathrm{r}, k) \mid \neg\, \texttt{Match}(v_i, \mathrm{r}, k) \\
\text{Trace expr e} & := & \texttt{Concatenate}(\mathrm{f}_1, \cdot\cdot, \mathrm{f}_n) \\
\text{Atomic expr f} & := & \texttt{SubStr}(v_i, \mathrm{p}_1, \mathrm{p}_2) \\
 & \mid & \texttt{ConstStr}(s) \\
 & \mid & \texttt{Loop}(\lambda w : \mathrm{e}) \\
\text{Position p} & := & \texttt{CPos}(k) \mid \texttt{Pos}(\mathrm{r}_1, \mathrm{r}_2, \mathrm{c}) \\
\text{Integer expr c} & := & k \mid k_1 w + k_2 \\
\text{Regular Expression r} & := & \texttt{TokenSeq}(\mathrm{T}_1, \cdot\cdot, \mathrm{T}_m) \\
\text{Token T} & := & C+ \mid [\neg C]+ \\
 & \mid & \text{SpecialToken}
\end{array}
$$



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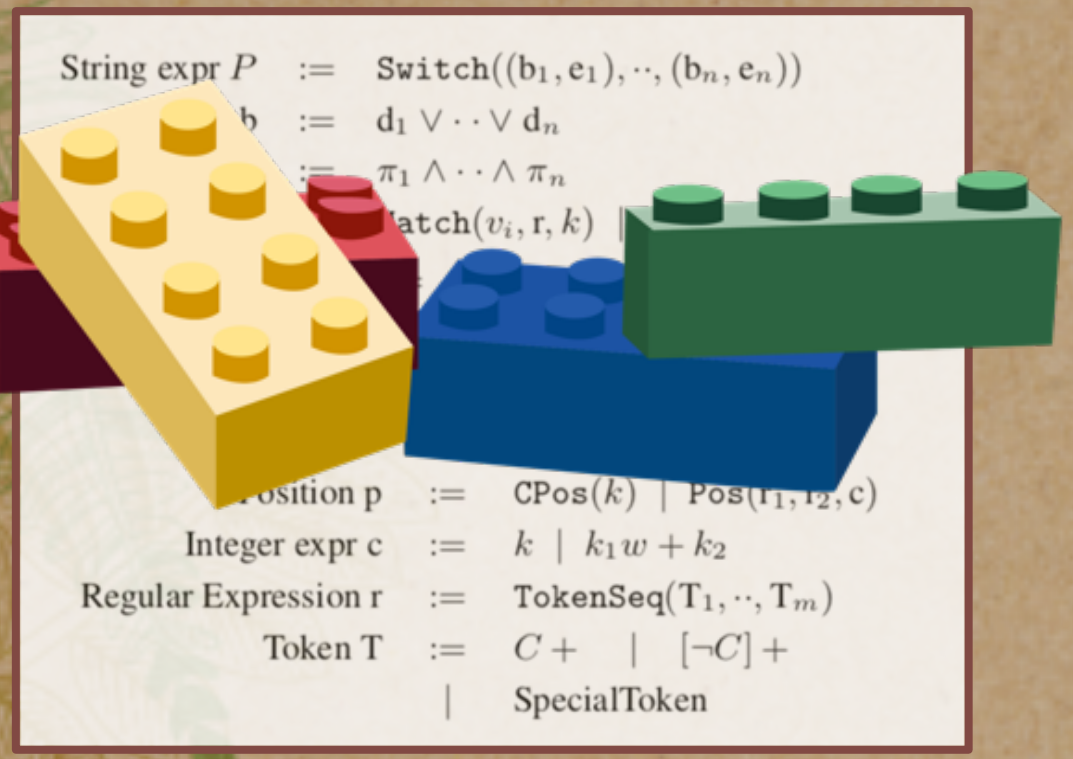
Programming by Example: Flash Fill (Gulwani, 2011)

The Flash Fill Domain-specific Language



String expr P := $\texttt{Switch}((b_1, e_1), \cdot\cdot, (b_n, e_n))$

b := $d_1 \vee \cdot\cdot \vee d_n$

:= $\pi_1 \wedge \cdot\cdot \wedge \pi_n$

$\texttt{atch}(v_i, r, k)$ |

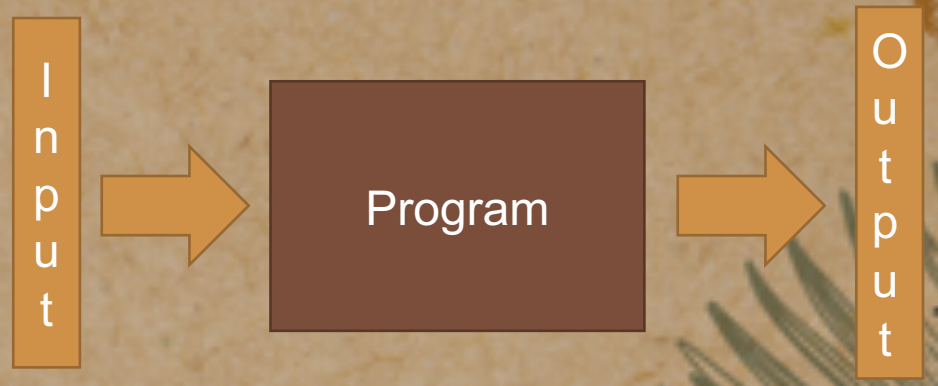
$\texttt{osition}$ p := $\texttt{CPos}(k)$ | $\texttt{Pos}(r_1, r_2, c)$

Integer expr c := k | $k_1 w + k_2$

Regular Expression r := $\texttt{TokenSeq}(T_1, \cdot\cdot, T_m)$

Token T := $C+$ | $[\neg C]+$

| SpecialToken



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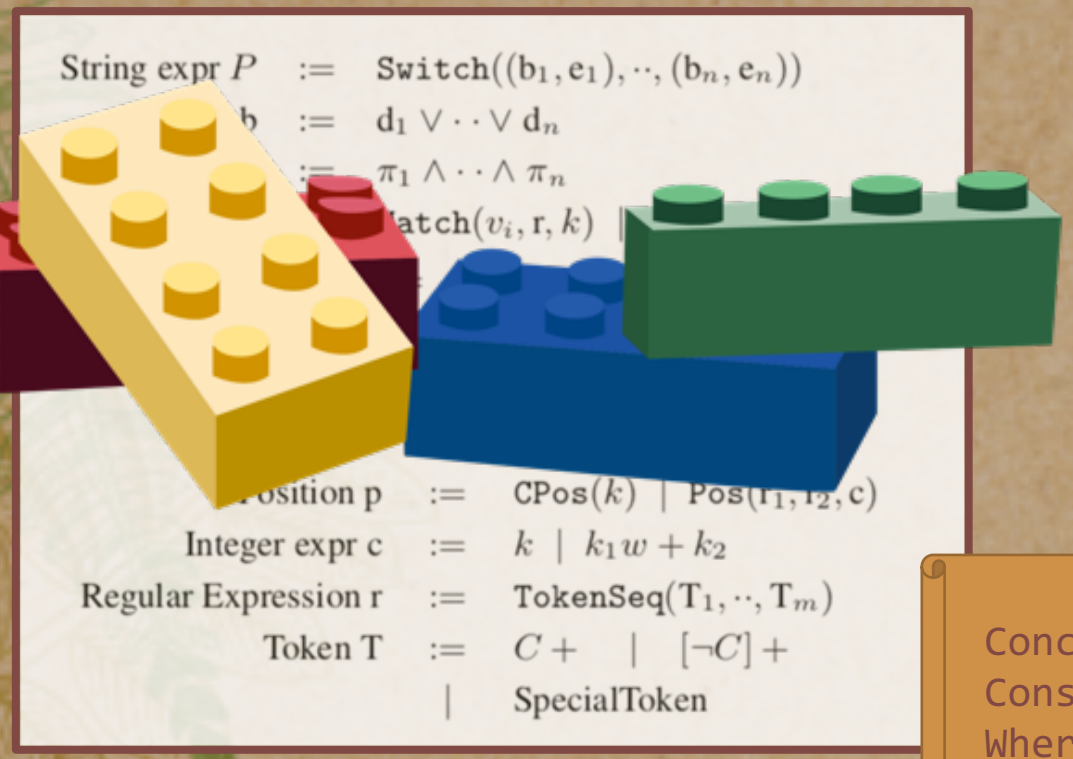
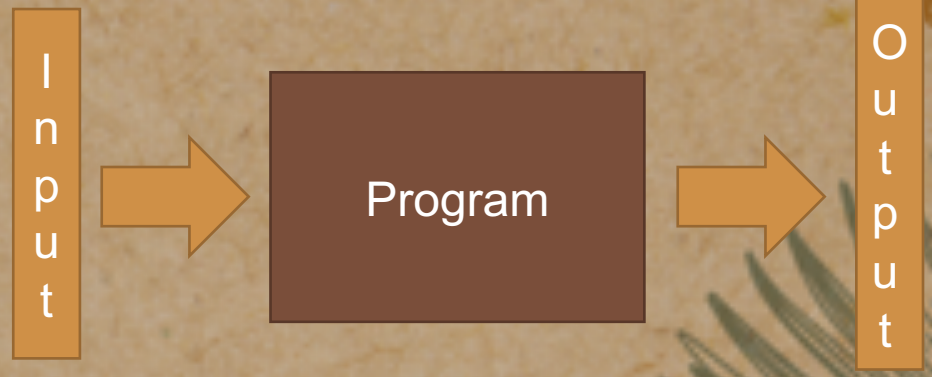
Programming by Example: Flash Fill (Gulwani, 2011)

The Flash Fill Domain-specific Language





An example generated program

```
Concatenate(Loop(λw : Concatenate(SubStr(v1,p1,p2)),
ConstStr(“ ”)), SubStr2(v1 , NonSpaceTok, -1))
Where p1 ≡ Pos(ϵ,NonSpaceTok,w), and
p2 ≡ Pos(NonSpaceTok, TokenSeq(SpaceTok, NonSpaceTok), w)
```

(source: Gulwani “Automating string processing in spreadsheets using input-output examples”, *POPL 2011)*

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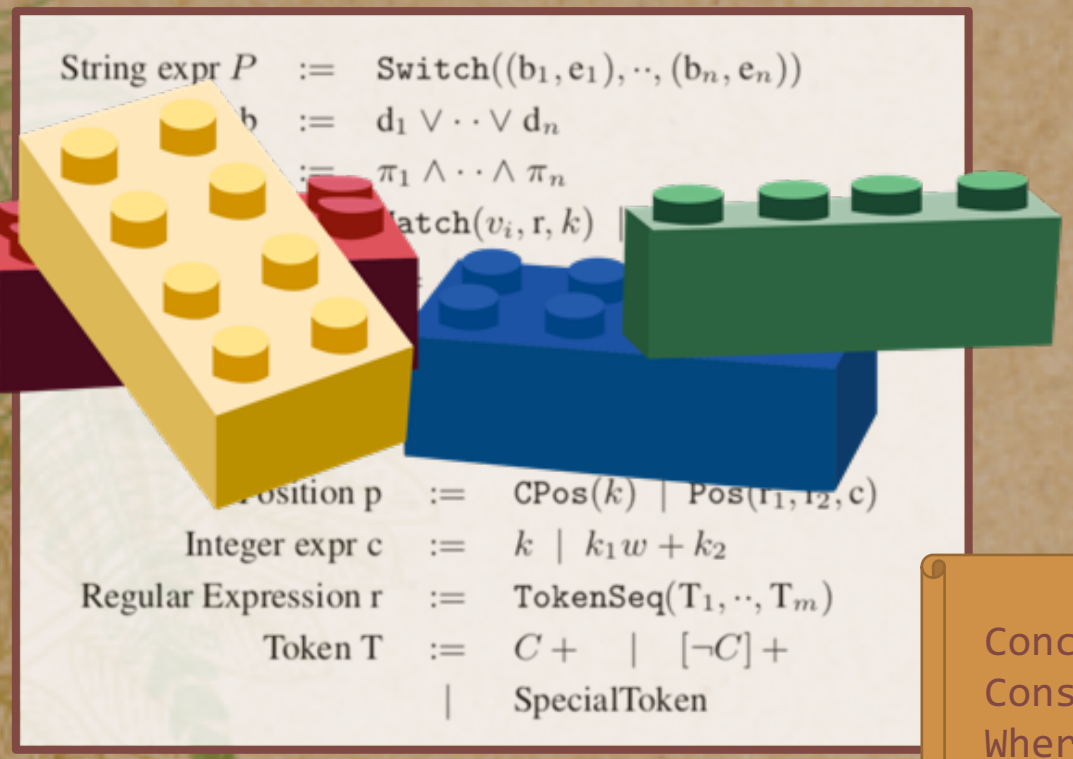
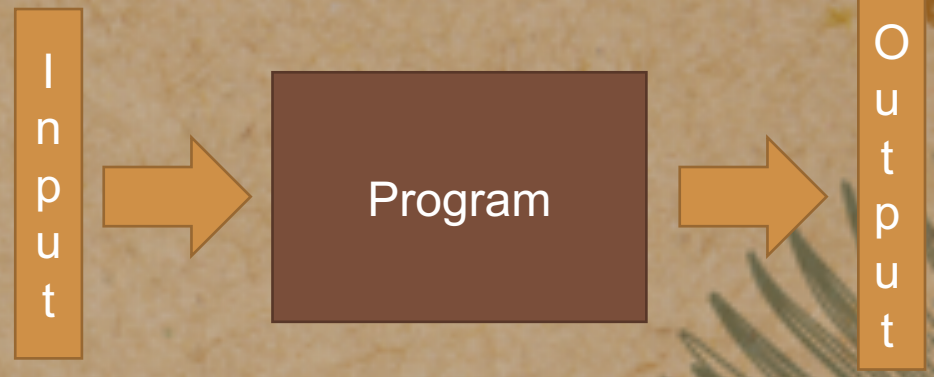
Programming by Example: Flash Fill (Gulwani, 2011)

The Flash Fill Domain-specific Language



String expr P	:=	$\texttt{Switch}((b_1, e_1), \cdot\cdot, (b_n, e_n))$
b	:=	$d_1 \vee \cdot\cdot \vee d_n$
	:=	$\pi_1 \wedge \cdot\cdot \wedge \pi_n$
	:=	$\texttt{atch}(v_i, r, k)$ |
osition p	:=	$\texttt{CPos}(k)$ | $\texttt{Pos}(r_1, r_2, c)$
Integer expr c	:=	k | $k_1 w + k_2$
Regular Expression r	:=	$\texttt{TokenSeq}(T_1, \cdot\cdot, T_m)$
Token T	:=	$C+$ | $[\neg C]+$
	|	SpecialToken



An exa… program

```
Concatenate(…                    ate(SubStr(v1,p1,p2)),
ConstStr("                       SpaceTok, -1))
Where p1 ≡                       nd
p2 ≡ Pos(Non…                    k, NonSpaceTok), w)
```

(source: Gulwani "Automating string p… …tput examples", *POPL 2011)*

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How does Artificial Programming work?

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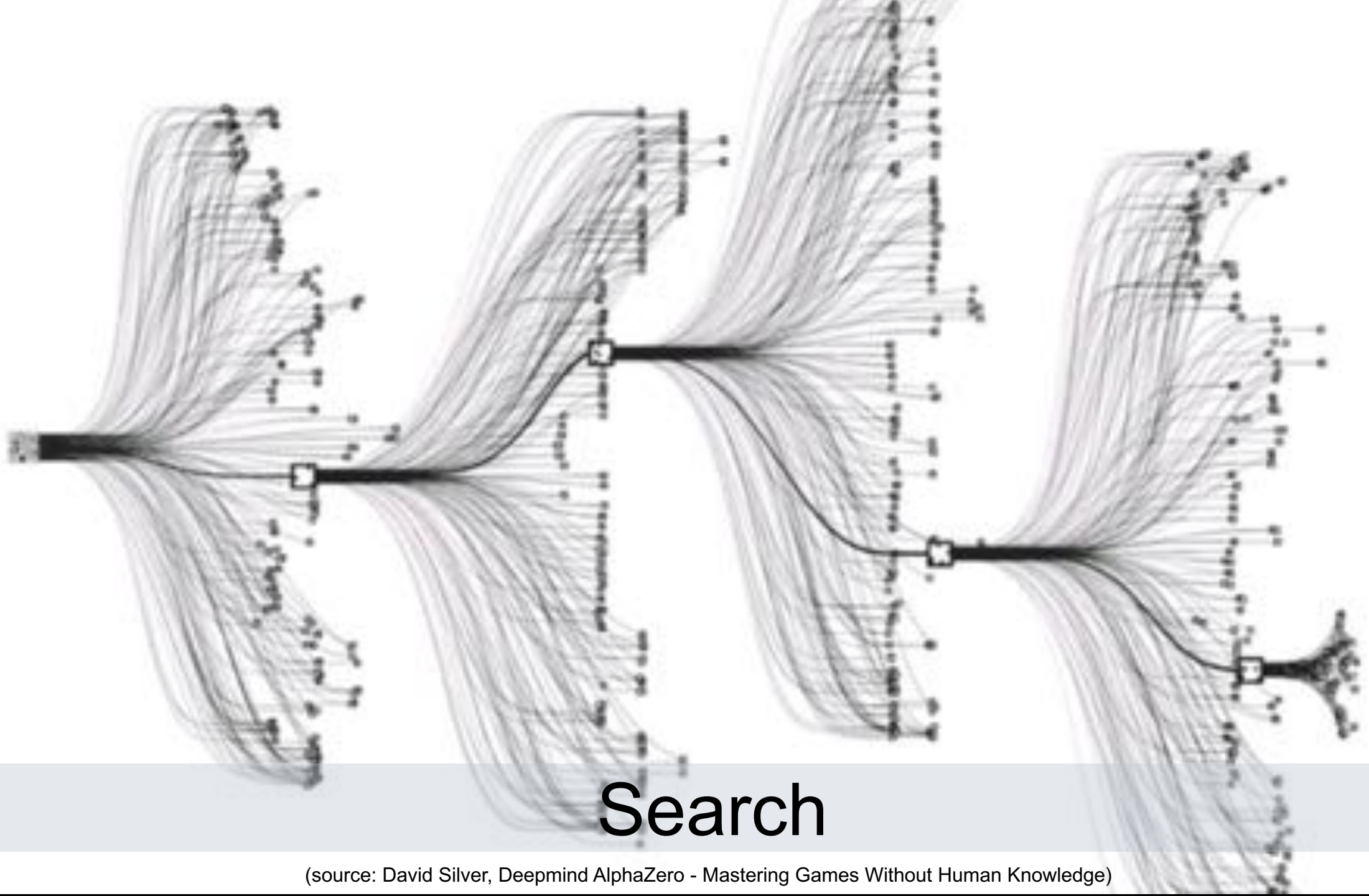

Search

(source: David Silver, Deepmind AlphaZero - Mastering Games Without Human Knowledge)

Artificial Programming works for specific domains

Artificial Programming

Text processing

Querying databases

?

Configuring networks

Drawing user interfaces

Artificial Gameplay

Go

Jeopardy

?

Monopoly

Starcraft

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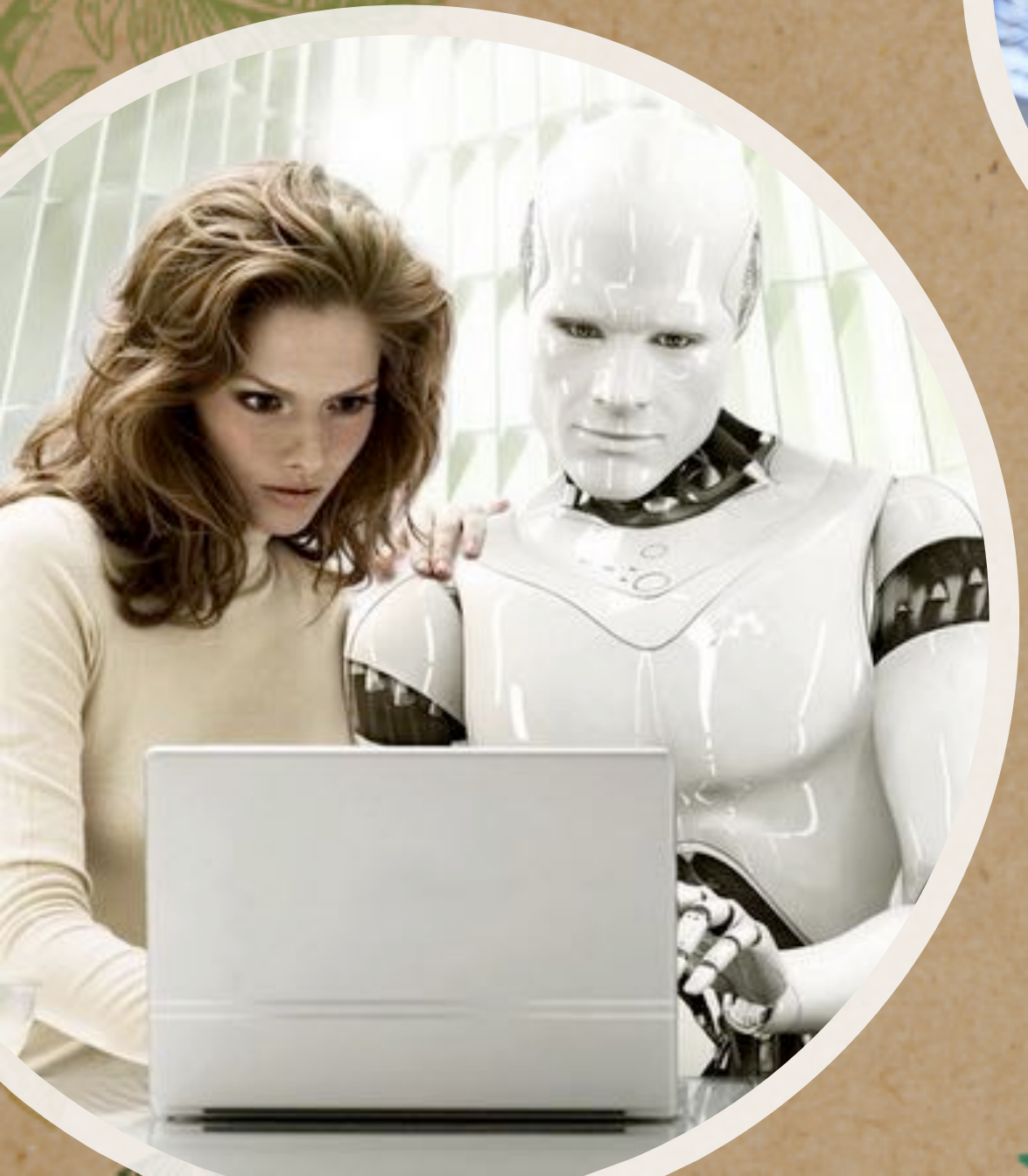

Will software developers soon be replaced by AI?

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Don't fall for the hype

NEURAL SKETCH LEARNING FOR CONDITIONAL PROGRAM GENERATION

Vijayaraghavan Murali, Letao Qi, Swarat Chaudhuri, and Chris Jermaine
Department of Computer Science
Rice University
Houston, TX 77005, USA.
{vijay, letao.qi, swarat, cmj4}@rice.edu

ABSTRACT

We study the problem of generating source code in a strongly typed, Java-like

DEEPCODER: LEARNING TO WRITE PROGRAMS

Matej Balog*
Department of Engineering
University of Cambridge

Alexander L. Gaunt, Marc Brockschmidt,
Sebastian Nowozin, Daniel Tarlow
Microsoft Research

ABSTRACT

We develop a first line of attack for solving programming competition-style problems from input-output examples using deep learning. The approach is to train a

ARTIFICIAL INTELLIGENCE

The Military Just Created An AI That Learned How To Program Software

Futurism.com, April 26, 2018

New Scientist

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NEWS & TECHNOLOGY 22 February 2017

AI learns to write its own code by stealing from other programs

New Scientist, February 22, 2017

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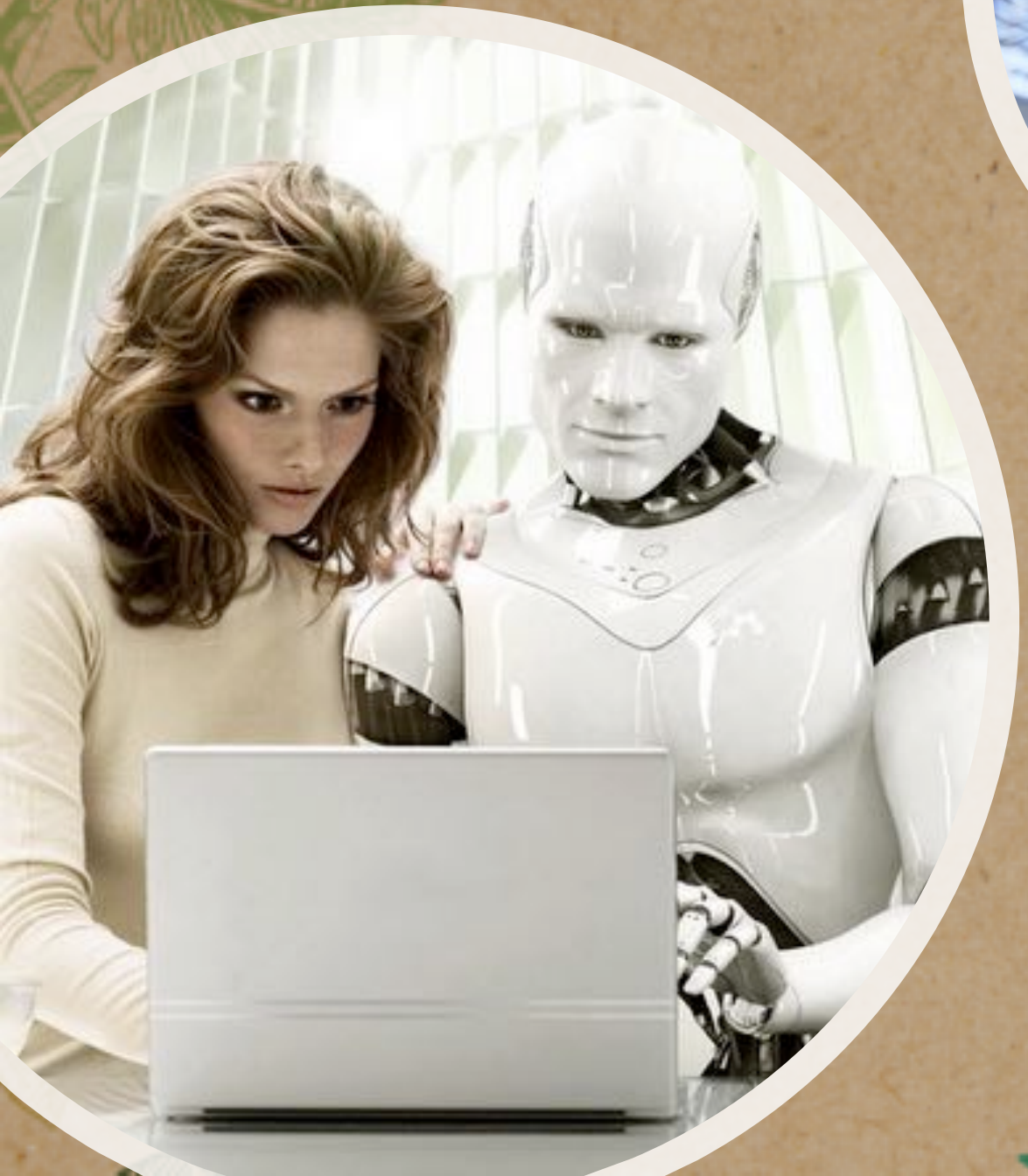

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