Leveraging LLMs as **Analogical Reasoning** Engines to enhance **Programming-by-Example** Experiences



Sumit Gulwani PROSE team @ Microsoft

SEMLA Symposium, Canada June 2023

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11	Moumita Mazumdar				
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9	Dibyush Jena				
10	Khushi Goel				
11	Moumita Mazumdar				
12	Srushti Chipde				

99% of computer users don't know programming and struggle with repetitive tasks!





ExcelExperts.com

Excel Consultancy, VBA Consultancy, Training and Tips Call:+4420812

Flash Fill: a programming-by-example feature



CNN: "Excel 2013's coolest new feature that should have been available years ago"

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4	Jayant Krishna	krishna, JAYANT		
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6	Sarah Iqbal	iqbal, SARAH		
7	Shruti Sunderasan	sunderasan, SHRUTI		
8	Utsav Thapliyal	thapliyal, UTSAV		
9	Dibyush Jena	jena, DIBYUSH		
10	Khushi Goel	goel, KHUSHI		
11	Moumita Mazumdar	mazumdar, MOUMITA		
12	Srushti Chipde	chipde, SRUSHTI		

<u>Scientific breakthrough</u>: Efficient synthesis of programs from 1+ examples.

[POPL '11, Gulwani, Automating string processing in spreadsheets using input-output examples]

-	Δ		
1	Name	В	
2	Firstname Lastname	Student ID	beast-academy
3	Sumay Gulwani	123456	F-1234#lastnam
4	Andrew Concini	567238	S-5672#gulwani
5	Ion Kotes	756497	A-7564#cencini
5	Jan Kotas	672934	J-6729#kotas
6	Mariya Sergienko	498523	M-4985#sergien
7	Steven Thorpe	123098	S-1230#thorpe
8	Michael Neipper	892457	M-8924#neippe
9	Robert Zare	654634	R-6546#zare
10	Laura Giussani	247467	L-2474#giussani
11	Nancy Freehafer	768678	N-/680#ireenan
11	Alexander David	324356	x-7876#shane
12	Alexander Da	787687	M-2232#chopra
13	Kim Shalle	223256	G-8995#oberleit
14	Manish Chopra	899543	A-7896#zaki
15	Gerwald Oberlettine	789654	Y-5465#mckay
16	Amr Zaki	546587	A-2345#pinto
17	Yvonne McKay	234546	-
10	Amanda Pinto	rDala Loop Abbreview	1111
0	minle Bracket		-

Programming-by-example is a form of Analogical Reasoning



Analogies for Assessments













А









В





ASSISTANT



human cognition and problem-solving. It allows individuals to make sense of new information, transfer knowledge from one context to another, and find solutions to a wide range of challenges. This cognitive process is essential in various aspects of life, such as learning, communication, creativity, and decisionmaking.

Analogies for Math Theorems

An even number is made of kids who are all paired up. An odd number is made of kids who are all paired up except one lonely kid.

Theorem: Odd + Odd = Even Proof: The two lonely kids can now pair up.

What is Odd + Even? (sad voice) Odd Proof: There is no one to pair the lonely kid with.

What is Even + Even? (happy voice) Even Proof: There is no lonely kid to begin with.





Al is going to take over the world... and this is what Excel auto-populated today.

К	L	М	N
	DEC	December	
	NOV	November	
	ОСТ	Octember	
	APR	Aprember	

The Flash Fill Fail

 \sim

PROgram	Synthesis using	Examples

"Al is going to take over the world..." Octember 23, 2018

A	В	С
1 DEC	December	
2 NOV	November	
3 OCT	Octember	A CARA
4 APR	Aprember	
AUG	Augember	
5 FEB	Febember	1000
7 JAN	Janember	
R IUL	Julember	
	Junember	
MAR	Marember	
1 MAY	Mayember	
2 SEP	Sepember	
2 561		

Semantic Transformations

City	Airport code
Brussels	BRU
Boston	BOS
Tokyo	HND

Device	Color
iPhone 11 512GB - Red AT&T	Red
iPhone 11 512GB - Space Gray AT&T	Space Gray
iPhone 11 128GB - Midnight Green Verizon	Midnight Green
iPhone 11 64GB - Silver T-Mobile	Silver

Numeral	Dutch word
1	een
2	twee
3	drie

Sentence	Language learning Exercise
I am James.	I James.
We are in our classroom.	We in our classroom.
My parents are in Madrid.	My parents in Madrid.
The ceiling is high.	The ceiling high.

Requires knowledge bases, entity recognition, or natural language understanding

Flash Fill DSL

top-level expr $T := C \mid ifThenElse(B, C, T)$ string expr $C := A \mid Concatenate(A, C)$ atomic expr $A := SubString(x, P, P) \mid Const(w)$

position expr P := K | RegPos(x, R, K)

Flash Fill DSL (extended

top-level expr $T := C \mid ifT$ string expr $C := A \mid Concate_{ng_{max}}$ atomic expr A := SubString $SemMap(x, _{able})$ position expr $P := K \mid RegP$ SemPos(x,

Key Idea: Combine Flash Fill + LLM-based skills

[OOPSLA '21: Verbruggen et al, "Semantic programming by example with pi

Hey Chat GPT, finish this building...

Your skills are irreplaced in 9

Chat

LLMs on syntactic transformations

GPT-3: Often can't do simple tasks or requires too many examples.

Month	First 3 chars	First 4 chars
January	Jan	Janu
February	Feb	Febr
March	Mar	Marc
April	Apr	Apri
September	Sep	Sep

GPT-4: Very powerful analogical reasoning capabilities!



Month	First 4 chars
January	Janu
February	Febr
March	Marc
April	Apri
September	Sept

Analogical Reasoning

EXAMPLE 3 (Directory Name Extraction). Consider the following example taken from an excel online help forum.

Input v_1	Output
Company\Code\index.html	Company Code
Company\Docs\Spec\specs.doc	$Company \setminus Docs \setminus Spec \setminus$

USER Input: "Company\Code\index.html" Output: "Company\Code\"

> Input: "Company\Docs\Spec\specs.doc" Output:

ASSISTANT "Company\Docs\Spec\"



Analogical Reasoning

Input v_1	Output
BTR KRNL WK CORN 15Z	15Z
CAMP DRY DBL NDL 3.6 OZ	3.6 OZ
CHORE BOY HD SC SPNG 1 PK	1 PK
FRENCH WORCESTERSHIRE 5 Z	5 Z
O F TOMATO PASTE 6 OZ	6 OZ



Input: "BTR KRNL WK CORN 15Z" Output: "15Z"

Inputs: "CAMP DRY DBL NDL 3.6 OZ", "CHORE BOY HD SC SPNG 1 PK", "FRENCH WORCESTERSHIRE 5 Z", "O F TOMATO PASTE 6 OZ" Outputs:

ASSISTANT "3.6 OZ", "1 PK", "5 Z", "6 OZ"

Analogical Reasoning

Input v_1	Output
International Business Machines	IBM
Principles Of Programming Languages	POPL
International Conference on Software Engineering	ICSE

USER

Input: "International Business Machines" Output: "IBM"

Inputs: "Principles <u>Of</u> Programming Languages", "International Conference on Software Engineering", "Industrial Credit and Investment Corporation of India"

Outputs:

ASSISTANT "POPL", "ICSE", "ICICI"

Python Program Generation

SYSTEM

You are an expert Python user. I will give you a string transformation task. The task involves converting input strings to output strings. You have to find the Python program that will generate the output string given the input string.

USER

Input: "International Business Machines"
Output: "IBM"
Input: "Principles Of Programming Languages"
Output: "POPL"
Input: "International Conference on Software Engineering"
Output: "ICSE"
Input: "Industrial Credit and Investment Corporation of India"
Output: "ICICI"

ASSISTANT



You can use the following Python program to generate the output string given the input string: ```python def acronym_generator(input_string): words = input_string.split() acronym = "" for word in words: acronym += word[0].upper() return acronym

Test-driven Development

Iteratively write down a test and edit code to satisfy it.

https://testing.googleblog.com/2014/04/the-real-test-driven-development.html

Google Testing Blog

The *Real* Test Driven Development

Tuesday, April 01, 2014

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Update: APRIL FOOLS!



Test-Driven Synthesis

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Abstract

Programming-by-example technologies empower end-users to create simple programs merely by providing input/output examples. Existing systems are designed around solvers specialized for a specific set of data types or domain-specific language (DSL). We present a program synthesizer which can be parameterized by an arbitrary DSL that may contain conditionals and loops and therefore is able to synthesize programs in any domain. In order to use our synthesizer, the user provides a sequence of increasingly sophisticated input/output examples along with an expert-written DSL definition. These two inputs correspond to the two key ideas that ing table layouts or reformatting strings merely by providing input/output examples. Present PBE technologies are designed for a specific set of data types usually either by using an SMT solver or similar technology [30, 33] and being limited to efficiently handling only those data types whose operations map well to the SMT solver's theories or by creating a domain-specific language (DSL) for the task in concert withs a program synthesis algorithm capable of producing programs in that DSL [8, 11, 18]. LaSy¹ instead is able to synthesize programs in arbitrary domains specified by an expert-written DSL. In order to efficiently support arbitrary domains, we developed a synthesizer that combines two key ideas.

Python Program Generation (using failure-guided iteration)

USER Input: "International Business Machines" Output: "IBM" Input: "Principles <u>Of</u> Programming Languages"

Output: "POPL" Input: "International Conference on Software Engineering" Output: "ICSE" Input: "Industrial Credit and Investment Corporation of India" Output: "ICICI"

ASSISTANT You can use the following Python program to generate the output string given the input string:



```python
def acronym\_generator(input\_string):
 words = input\_string.split()
 acronym = ""
 for word in words:
 acronym += word[0].upper()

return acronym

#### **Python Program Generation** (using failure-guided iteration)

USER But this generates the output "ICOSE" on the input "International Conference on Software Engineering".

ASSISTANT

Apologies for the oversight. I see that the program is not handling the prepositions correctly. Here's an updated version of the program that should work correctly:



#### Python Program Generation (using failure-guided iteration)

USER But this generates the output "PPL" on the input "Principles <u>Of</u> Programming Languages".

ASSISTANT



Apologies for the confusion. I misunderstood the requirement. Here's the corrected version of the program that should work correctly for all the given examples:

```python

def acronym_generator(input_string):

words = input_string.split()

acronym = ""

for word in words:

if word[0].isupper():

acronym += word[0]

return acronym

Python Program Generation

SYSTEM

You are an expert Python user. I will give you a string transformation task. The task involves converting input strings to output strings. You will have to find the Python program that will generate the output string given the input string.

USER

Input: "Finish slides 3 and 4 Sumit Gulwani" Output: "Sumit"

Input: "Find the video Ben Zorn" Output: "Ben"

ASSISTANT



You can use the following Python program to generate the output string given the input string: ```python

def find name(input string):

words = input string.split()

for word in words:

if word[0].isupper():



return word

Analogy Solving

SYSTEM

I will provide you an analogy problem related to string transformations. I will give you few input-output examples of the analogy. I will then provide a list of comma-separated inputs. You should then generate a list of comma-separated outputs. USER

Input: "Finish slides 3 and 4 Sumit <u>Gulwani</u>" Output: "Sumit"

Input: "Find the video Ben Zorn" Output: "Ben"

Inputs: "Do the conclusion Ashish Tiwari", "Think of a good title Nikhil Swamy", "Insert some visuals Nikolaj <u>Bjorner</u>" Outputs:

ASSISTANT "Ashish", "Nikhil", "Nikolaj"

Analogy Explanation



Can you explain the analogy? USER

Certainly! The analogy here is that each input ASSISTANT string contains a task followed by a person's name. The output is the first name of the person associated with the task. In each example, the first name appears right before the last name, which is the last word in the input string. So, the transformation involves extracting the first name from the input string. Python Program Generation

\$

ASSISTANT

USER

Sure! Here's a simple Python program that takes an input string and returns the respective output (the first name of the person mentioned at the end of the sentence):

Can you find a Python program that converts an

above input into the respective output.

```python
def extract\_first\_name(input\_string):

words = input\_string.split()

first\_name = words[-2]

return first\_name

### Can't generate program, but can solve the analogy.

| -                        |              |
|--------------------------|--------------|
| Input $v_1$              | Output       |
| Dr. Eran Yahav           | Yahav, E.    |
| Prof. Kathleen S. Fisher | Fisher, K.   |
| Bill Gates, Sr.          | Gates, B.    |
| George Ciprian Necula    | Necula, G.   |
| Ken McMillan, II         | McMillan, K. |

USER

Input: "Dr. Eran Yahav" Output: "Yahav, E." Input: "Prof. Kathleen S. Fisher" Output: "Fisher, K."

Inputs: "Bill Gates, Sr.", "George Ciprian Necula", "Ken McMillan, II" Outputs:

ASSISTANT "Gates, B.", "Necula, G.", "McMillan, K."

## Summary: GPT-4 on Flash Fill Tasks

GPT4 is super-impressive at analogical reasoning,

but generating programs from few examples is not its best seasoning.

Python programs it can generate for many cases, but with non-trivial workflows in some places. For Excel formulas or lower-resource languages, its performance is much worse and can cause damages.

GPT4 is super-impressive at analogical reasoning,

It can infer extra examples & explanations, which is very appealing.

This can boost the programming power of Flash Fill, while also enabling semantic transformations at will. But is it always better at analogies than Flash Fill? Actually no, sometimes it can make a big spill.

# Second last word

USER

### Analogical Reasoning Failure

Input: "sumit gulwani" Output: "sumit" Input: "doctor ashish tiwari" Output: "ashish" Input: "alpha beta gamma delta" Output: "gamma" Input: "first second third fourth fifth" Output: "fourth"

Inputs: "good morning", "life is good", "hope for the best" Outputs:



#### First 5 characters

### Analogical Reasoning Failure

Input: "january" Output: "janua" Input: "february" Output: "febru" Input: "november" Output: "novem" Input: "october" Output: "octob"

> Inputs: "september", "december", "august" Outputs:



USER

#### GPT-3

| Month     | First 3 chars | First 4 chars |
|-----------|---------------|---------------|
| January   | Jan           | Janu          |
| February  | Feb           | Febr          |
| March     | Mar           | Marc          |
| April     | Apr           | Apri          |
| September | Sep           | Sep           |



USER

An even number is made up of kids who are all paired up. An odd number is made up of kids who are all paired up except one lonely kid.

Input: What is odd + odd? Output: Happy voice Even. Because the lonely kids in the two odd numbers can now pair with each other.

#### GPT-4

| Month     | First 4 chars | First 5 chars |
|-----------|---------------|---------------|
| January   | Janu          | Janua         |
| February  | Febr          | Febru         |
| March     | Marc          | March         |
| April     | Apri          | April         |
| September | Sept          | Septem        |
|           | This shall h  | opofully bo   |

This shall hopefully be solved by GPT5.

| JUN | Junember |        |
|-----|----------|--------|
| MAR | Marember |        |
| MAY | Mayember |        |
| SEP | Sepember |        |
|     |          | Cione. |

5:00 AM · Oct 23, 2018 · Twitter for iPhone

12.5K Retweets 32K Likes

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<u>↑</u>,

**,**↑,

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 $\checkmark$ 

#### Flash Fill++: Richer Transformations & Readable code generation

| Input       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Output (3-hr bucket                                                        |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| CEDAR AVE 8 | & COTTAGE AVE; HORSHAM; 2015-12-11 @ 13:34:52;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Fri, 12PM - 3PM                                                            |
| RT202 PKWY; | MONTGOMERY; 2016-01-13 @ 09:05:41-Station:STA18;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Wed, 9AM - 12PM                                                            |
| ; UPPER GWY | ′NEDD; 2015-12-11 @ 21:11:18;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Fri, 9PM - 12AM                                                            |
| def         | <pre>derive_value(_input):<br/>text = _input.split(";")[2]<br/>part_0 = text.split(" ")[0]; part_1 = text.split(" ")<br/>date = datetime.datetime.strptime(part_0, "%Y-%m-%d")<br/>time = datetime.datetime.strptime(part_1, "%H:%M:%S")<br/>base_value = datetime.timedelta(hours=time.hour, minut<br/>seconds=time.second, microseconds=time.microsecond)<br/>delta_value = datetime.timedelta(hours=3)<br/>time_str = (time - base_value % delta_value).strftime<br/>rounded_up_next = (time - base_value % delta_value) +<br/>computed_value = time_str + "-" + rounded_up_next.strf<br/>return date.strftime("%a") + ", " + computed_value</pre> | <pre>[2][:8] tes=time.minute, ) ("%#I%p") delta_value ftime("%#I%p")</pre> |

31

#### Available in Excel online, Power Apps, Power Automate!



#### NEW Formula by Example 10x Better than Flash Fill

16K views · 6 days ago



Microsoft Excel: Users can now easily access formulas with this new update

"time spent tweaking the expressions, all gone!"

#### "saved 16 hours of work, just 4 days after release"

[POPL '23: Cambronero et al, Flash Fill++: Scaling Programming by Examples by Cutting to the Chase]

## Flash Fill++ for Education

### Flash Fill now appears in grade 6 computing textbooks.

| A | A             | 8                            |            |
|---|---------------|------------------------------|------------|
| 1 | Phone Numbers | Phone Numbers with STD Codes | • 17 •     |
| 2 | 1145623456    | (11)45623456                 |            |
| 3 | 1122189567    | (11)22189567                 | KINEMASTER |
| 4 | 2243568906    | (22)43568906                 |            |
| 5 | 4422189037    | (44)22189037                 | 1          |
| 6 | 3322896743    | 3 (33)22896743               |            |

 Fig. 3.27 Phone numbers formatted using Flash Fill option

Thus, Flash Fill can be used for extracting, inserting and formatting the data qui This feature can even reverse text, numbers, dates and much more.

Kevs

#Magic

1. The shortcut key combination for Flash Fill is Ctrl + E

2. The Flash Fill option is also available on the Data tab.



"Son, now I understand your research for the first time." ----My dad after Flash Fill paper

### **Table Extraction**

| style="text-align: center;"  {{Sort 01 [[Super Bowl   1]]}}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| style="background:#d0e7ff;" {{Sort Green Bay Packers 01 [[1966 Green Bay Packers season Green Bay Packers]] <sup>‡</sup> }}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | }                                                                                           |
| style="text-align: center;"  {{Sort 3510 35–10}}<br>style="text-align: center;"  {{Sort 3510 35–10}}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                             |
| (Sort Los Angeles Memorial Coliseum 01 [[Los Angeles Memorial Coliseum]]]}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | I,1967,Green Bay Packers 01,35-10,Kansas City Chiefs 01,Los Angeles Memorial Colise         |
| [Sort]Pasadena, California 01][[Los Angeles]], [[California]]{{#tag:ref Both [[Los Angeles, California Los Angeles]] and [[Pasadena, C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Ca III,1969,New York Jets 01,16-7,Indianapolis Colts 01,Orange Bowl 02 IV,1970,Kansas       |
| style="text-align: center;"  {{Sort 061946 61,946}}<br>style="text-align: center;"  <ref>{{Cite journal llast=Maule  first=Tex  url=http://sportsillustrated.cnn.com/vault/article/magazine/MAG1(</ref>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | C10 V,1971,Indianapolis Colts 02,16-13,Dallas Cowboys 01,Orange Bowl 03 VI,1972,Dallas      |
| ······································                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | VII,1973,Miami Dolphins 02,14-7,Washington Redskins 01,Los Angeles Memorial Coliseur        |
| style="text-align: center;"  {{Sort[02][[Super Bowl II]I]]]}}<br>[Dts[1968].January[14]}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | IX,1975,Pittsburgh Steelers 01,16-6,Minnesota Vikings 03,Tulane Stadium 03 X,1976,F         |
| style="background:#d0e7ff;" {{Sort Green Bay Packers 02 [[1967 Green Bay Packers season Green Bay Packers]] <sup>‡</sup> (2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | (2)) XI.1977.Oakland Raiders 02.32-14.Minnesota Vikings 04.Rose Bowl 01 XII.1978.Dallas     |
| style="text-align: center;"  {{Sort 3314 33–14}}<br>style="text-align: center;" //Sort Oakland Baiders 01/[[1967 Oakland Baiders season Oakland Baiders]] <sup>^<th>XIII.1979.Pittsburgh Steelers 03.35-31.Dallas Cowhovs 05.Orange Bowl 05. XIV.1980.Pi</th></sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | XIII.1979.Pittsburgh Steelers 03.35-31.Dallas Cowhovs 05.Orange Bowl 05. XIV.1980.Pi        |
| [Sort Orange Bowl 01][[[Miami Orange Bowl]Orange Bowl]]]}}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1981 Oskland Daidens 03 27-10 Dhiladelphia Eagles 01 Louisiana Superdome 02 XVI             |
| [Sort[Miami, Florida 01][[Miami]], [[Florida]]{{#tag:refl[[Miami Gardens, Florida[Miami Gardens]] was incorporated as a [[subi<br>"bula="text" align: center;" [[Soci075542]55542]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1901,000,000 Martine Redshing 02 27 17 Minni Delphing 04 Dece Revil 03 W/III 1080 Oc        |
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| style="background:#fcc;" {{Sort New York Jets 01 [[1968 New York Jets season New York Jets]] <sup>^</sup> }}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | XXIII,1989,San Francisco 49ers 03,20-16,Cincinnati Bengals 02,Joe Robbie Stadium 01         |
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#### [PLDI '14, Le & Gulwani, FlashExtract: a framework for data extraction by examples]

#### PROSE Playground



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PROSE SDK About

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| <b>PROSE Playground</b><br>Program Synthesis using Examples SDK                                                                                                                                                                                                                                                                                                                                                                                                         | Add file                                                           | <b>T</b><br>Reset                                                         | <b>←</b><br>Undo                                                    | →<br>Redo                                             | <b>C</b><br>Learn                                                              | Settings                      | <b>↓</b><br>Result |           | PROSE SDK<br>About |
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| <b>PROSE Playground</b><br>Program Synthesis using Examples SDK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Add file                                                                                                                                                                                                                    | <b>T</b><br>Reset                                                                                                                                                                                                                                            | <b>←</b><br>Undo                                                                                                                                                                        | →<br>Redo                                                                                                                                                                       | C                                                                                                                             | Settings                                                                                                                                                                                                                                                                                                                        | <b>⊻</b><br>Result                                                                                                                                                                                                                                                                                                       | PROSE SDK<br>About |
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| BlueLabel       GreenLabel         style="text-align: center;"  {{Sort 01 [Super Bowl]         {{Dts 1967 January 15}}         style="background:#d0e7ff;" {{Sort Green Bay Pac         style="background:#d0e7ff;" {{Sort J510 35–10}}         style="background:#fcc;" {{Sort J510 35–10}}         style="background:#fcc;" {{Sort Kansas City Chiefs         [{Sort Los Angeles Memorial Coliseum 01 [[Los Angeles]], [[Ca         style="text-align: center;"  {{Sort 061946 61,946}}         style="text-align: center;"  {{Sort 02 [Super Bowl II         {{Dts 1968 January 14}}         style="background:#fcc;" {{Sort Oakland Raiders 0         {{Sort Orange Bowl 01 [[Miami Orange Bowl Orang         {{Sort Orange Bowl 01 [[Miami]], [[Florida]]{{#tag:rd         style="text-align: center;"  {{Sort 03 [[Super Bowl II]         {{Dts 1969 January 12}}         style="background:#fcc;" {{Sort New York Jets 01 [ <th><pre>)))} kers 01 [[196 001][[1966 k geles Memo lifornia]]{{#ta Maule  first= 1 ]]}&gt;<!--Dur kers 02 [[197 1 [[1967 Oal e Bowl]]}} ef[[[Miami Gi tp://aol.spor ]111]]} [1968 New ^ } p=note nam tp://www.sp</pre--></pre></th> <th>66 Green Bay [<br/>(ansas City Ch<br/>rial Coliseum]]<br/>ag:ref Both [[Lo<br/>Tex  url=http://s<br/>ring the AFL-Ni<br/>67 Green Bay [<br/>kland Raiders s<br/>ardens, Florida<br/>tingnews.com/<br/>York Jets seaso<br/>8 Baltimore Col<br/>e=b /&gt;}}<br/>ortingnews.cor</th> <th>Packers sea<br/>iefs season<br/>}}<br/>os Angeles,<br/>sportsillustra<br/>FL merger,<br/>Packers sea<br/>season Oak<br/>a Miami Gar<br/>a Miami Gar<br/>a Miami Gar<br/>on New Yorl<br/>ts season E</th> <th>ason Green<br/> Kansas Cit<br/>California L<br/>ated.cnn.col<br/>As the Colts<br/>ason Green<br/>(land Raider<br/>rdens]] was<br/>08-01-15/su<br/>k Jets]]<sup<br>Baltimore Co</sup<br></th> <th>Bay<br/>y Chi<br/>os Ai<br/>m/vai<br/>s mov<br/>Bay<br/>rs]]<s<br>incor<br/>incor<br/>iper-k<br/>&gt;^<!--:<br-->olts]]&lt;</s<br></th> <th>49 rows 1 c<br/>Super Bowl<br/>Super Bowl</th> <th>BlueLa           I           II           III           IV           V           VI           VII           VIII           IX           X           XII           XIII           XIV           XVI           XVI           XVI           XVII           XVII           XVII           XVII           XVIII           XIX</th> <th></th> | <pre>)))} kers 01 [[196 001][[1966 k geles Memo lifornia]]{{#ta Maule  first= 1 ]]}&gt;<!--Dur kers 02 [[197 1 [[1967 Oal e Bowl]]}} ef[[[Miami Gi tp://aol.spor ]111]]} [1968 New ^ } p=note nam tp://www.sp</pre--></pre> | 66 Green Bay [<br>(ansas City Ch<br>rial Coliseum]]<br>ag:ref Both [[Lo<br>Tex  url=http://s<br>ring the AFL-Ni<br>67 Green Bay [<br>kland Raiders s<br>ardens, Florida<br>tingnews.com/<br>York Jets seaso<br>8 Baltimore Col<br>e=b />}}<br>ortingnews.cor | Packers sea<br>iefs season<br>}}<br>os Angeles,<br>sportsillustra<br>FL merger,<br>Packers sea<br>season Oak<br>a Miami Gar<br>a Miami Gar<br>a Miami Gar<br>on New Yorl<br>ts season E | ason Green<br> Kansas Cit<br>California L<br>ated.cnn.col<br>As the Colts<br>ason Green<br>(land Raider<br>rdens]] was<br>08-01-15/su<br>k Jets]] <sup<br>Baltimore Co</sup<br> | Bay<br>y Chi<br>os Ai<br>m/vai<br>s mov<br>Bay<br>rs]] <s<br>incor<br/>incor<br/>iper-k<br/>&gt;^<!--:<br-->olts]]&lt;</s<br> | 49 rows 1 c<br>Super Bowl<br>Super Bowl | BlueLa           I           II           III           IV           V           VI           VII           VIII           IX           X           XII           XIII           XIV           XVI           XVI           XVI           XVII           XVII           XVII           XVII           XVIII           XIX |                    |
| <includeonly> }</includeonly><br> -<br>  style="text-align: center;"  {{Sort 04 [[Super Bowl I\<br> {{Dts 1970 January 11}}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>[</b>   ∨]]}}                                                                                                                                                                                                            |                                                                                                                                                                                                                                                              |                                                                                                                                                                                         |                                                                                                                                                                                 |                                                                                                                               | Super Bowl                                                                                                                                                                                                                                                                                                                      | XX<br>XXI<br>XXII                                                                                                                                                                                                                                                                                                        |                    |

| <b>PROSE</b> Playaround                                                                                                                                                                       | +                                                                                                                                                 | <b>m</b>        | ←                | $\rightarrow$                                                                                           | 2                                                                    | ø           | <b>1</b>       | PR             | OSE SDK  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------|----------------|----------------|----------|
| Program Synthesis using Examples SDK                                                                                                                                                          |                                                                                                                                                   | Beset           |                  | Dada                                                                                                    | Loorn                                                                | Cottings    | Desult         |                | About    |
|                                                                                                                                                                                               | Add file                                                                                                                                          | Reset           | Undo             | Redo                                                                                                    | Learn                                                                | Settings    | Result         |                |          |
|                                                                                                                                                                                               |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Output      | Progråm viewer | Disambiguation |          |
| BlueLabel GreenLabel YellowLabel                                                                                                                                                              |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | 49 rows 2 c | olumns         |                |          |
| style="text-align: center;"  {{Sort 01 [Super Bowl ]                                                                                                                                          | ]]}}                                                                                                                                              |                 |                  |                                                                                                         |                                                                      | Blu         | eLabel         | GreenLabel     | <u>^</u> |
| style="background:#d0e7ff:" {{Sort Green Bay Page                                                                                                                                             | ckers 01III1                                                                                                                                      | 966 Green Ba    | v Packers sea    | asonlGreen                                                                                              | Bav                                                                  | Super Bowl  | I 19           | 967            |          |
| style="text-align: center;"  {{Sort 3510 35–10}}                                                                                                                                              |                                                                                                                                                   |                 | ,                |                                                                                                         |                                                                      | Super Bowl  |                |                |          |
| style="background:#fcc;" {{Sort Kansas City Chief                                                                                                                                             | s 01 [[1966                                                                                                                                       | Kansas City C   | Chiefs season    | Kansas Cit                                                                                              | y Ch                                                                 | Super Bowl  |                |                |          |
| {{Sort Los Angeles Memorial Collseum 01 [[Los Angeles]]. [[Ca                                                                                                                                 | alifornia]]{{#                                                                                                                                    | tad:reflBoth [[ | Los Anaeles.     | CalifornialL                                                                                            | os Ai                                                                | Super Bowl  | IV             |                |          |
| style="text-align: center;"  {{Sort 061946 61,946}}                                                                                                                                           |                                                                                                                                                   |                 | ,                |                                                                                                         |                                                                      | Super Bowl  |                |                |          |
| style="text-align: center;"  <ref>{{Cite journal  last=</ref>                                                                                                                                 | Maule  first                                                                                                                                      | =Tex  url=http: | //sportsillustra | ated.cnn.co                                                                                             | m/vai                                                                | Super Bowl  | V<br>          |                |          |
| -<br>  style="text-align: center:"  {{Sort[02][Super Bow] ]                                                                                                                                   | ]]}} Di</td <th>uring the AFL-</th> <th>NFL merger.</th> <td>As the Colts</td> <td>s mov</td> <td>Super Bowl</td> <td>VI</td> <td></td> <td></td> | uring the AFL-  | NFL merger.      | As the Colts                                                                                            | s mov                                                                | Super Bowl  | VI             |                |          |
| {{Dts 1968 January 14}}                                                                                                                                                                       |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Super Bowl  | VII            |                |          |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                                                                                              | kers 02 [[19                                                                                                                                      | 967 Green Ba    | y Packers sea    | ason Green                                                                                              | Bay                                                                  | Super Bowl  | VIII           |                |          |
| style="text-align: center;"  {{Sort 3314 33–14}}<br>  style="background:#fcc:" {{Sort Oakland Baiders (                                                                                       | )1)[[1967 ()                                                                                                                                      | akland Raider   | s seasonlOak     | land Raide                                                                                              | rell <s< td=""><td>Super Bowl</td><td>IX</td><td></td><td></td></s<> | Super Bowl  | IX             |                |          |
| {{Sort Orange Bowl 01 [[Miami Orange Bowl Orang                                                                                                                                               | ;;[[[1007 07<br>]e Bowl]]}}                                                                                                                       |                 | 3 3643011046     |                                                                                                         | 0]] -0                                                               | Super Bowl  | Χ              |                |          |
| {{Sort Miami, Florida 01 [[Miami]], [[Florida]]{{#tag:r                                                                                                                                       | ef [[Miami (                                                                                                                                      | Gardens, Flori  | da Miami Gar     | dens]] was                                                                                              | incor                                                                | Super Bowl  | XI             |                |          |
| style="text-align: center;"  {{Sort 075546 75,546}}                                                                                                                                           | ttp://ool.op/                                                                                                                                     | artingnowo oou  | m/nfl/atan/200   | 00 01 15/ou                                                                                             | nort                                                                 | Super Bowl  | <u></u>        |                |          |
|                                                                                                                                                                                               |                                                                                                                                                   | Junghews.com    | n/nn/story/200   | Jo-01-15/Su                                                                                             | ipei-r                                                               | Super Bowl  |                |                |          |
| style="text-align: center;"  {{Sort 03 [ <mark>Super Bowl I</mark>                                                                                                                            | <mark>  </mark>    ]]}}                                                                                                                           |                 |                  |                                                                                                         |                                                                      | Super Bowl  | XIII           |                |          |
| {{Dts 1969 January 12}}                                                                                                                                                                       |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Super Bowl  | XIV            |                |          |
| style="background:#fcc;" {{Sort New York Jets U1                                                                                                                                              | [[1968 New                                                                                                                                        | York Jets sea   | Ison New York    | < Jets]] <sup< td=""><td>)&gt;/<!--!</td--><td>Super Bowl</td><td>XV</td><td></td><td></td></td></sup<> | )>/ !</td <td>Super Bowl</td> <td>XV</td> <td></td> <td></td>        | Super Bowl  | XV             |                |          |
| style="background:#d0e7ff;" {{Sort Indianapolis Co                                                                                                                                            | ∬<br>olts 01 [[19€                                                                                                                                | 38 Baltimore C  | olts season E    | altimore Co                                                                                             | olts]]<                                                              | Super Bowl  | XVI            |                |          |
| {{Sort Orange Bowl 02 Orange Bowl (2)}}                                                                                                                                                       |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Super Bowl  | XVII           |                |          |
| {{Sort Miami, Florida 02 Miami, Florida (2) <ref grou<="" td=""><td>ıp=note nar</td><th>ne=b /&gt;}}</th><th></th><td></td><td></td><td>Super Bowl</td><td>XVIII</td><td></td><td></td></ref> | ıp=note nar                                                                                                                                       | ne=b />}}       |                  |                                                                                                         |                                                                      | Super Bowl  | XVIII          |                |          |
| style='text-align: center;   {{Sort[075369]75,369}}<br>  style="text-align: center;"  <ref>{{Cite journal lurl=h</ref>                                                                        | ttp://www.s                                                                                                                                       | portingnews.c   | om/archives/s    | superbowl/3                                                                                             | .html                                                                | Super Bowl  |                |                |          |
| <includeonly> }</includeonly>                                                                                                                                                                 |                                                                                                                                                   | p               |                  |                                                                                                         |                                                                      | Super Bowl  |                |                |          |
|                                                                                                                                                                                               |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Super Bowl  | ΧΧ             |                |          |
| style="text-align: center;"  {{Sort 04 [[Super Bowl ]]                                                                                                                                        | <mark>∨</mark>   ∨]]}}                                                                                                                            |                 |                  |                                                                                                         |                                                                      | Super Bowl  | XXI            |                |          |
|                                                                                                                                                                                               |                                                                                                                                                   |                 |                  |                                                                                                         |                                                                      | Super Bowl  | XXII           |                |          |

| <b>PROSE</b> Playground                                                                                                                                                                      | +                               | ش –              | ←                  | $\rightarrow$                                                                                              | 3                                                                      | •           | $\mathbf{\Lambda}$ |               | PROSE SDK |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------|--------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------|--------------------|---------------|-----------|
| Program Synthesis using Examples SDK                                                                                                                                                         | Add file                        | Reset            | Undo               | Redo                                                                                                       | Learn                                                                  | Settings    | Result             |               | About     |
|                                                                                                                                                                                              |                                 |                  |                    |                                                                                                            |                                                                        | Output      | Program viewe      | er Disambigua | tion      |
| BlueLabel GreenLabel YellowLabel                                                                                                                                                             |                                 |                  |                    |                                                                                                            |                                                                        | 49 rows 2 c | olumns             |               |           |
| style="text-align: center;"  {{Sort 01 [Super Bowl ]                                                                                                                                         | ]]}}                            |                  |                    |                                                                                                            |                                                                        | Blu         | eLabel             | GreenLa       | bel       |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                                                                                             | ckers 01 [[19                   | ∂66 Green Bav    | √ Packers sea      | ason Green                                                                                                 | Bay                                                                    | Super Bowl  |                    | 1967          |           |
| style="text-align: center;"  {{Sort 3510 35–10}}                                                                                                                                             | 111                             |                  |                    | I                                                                                                          |                                                                        | Super Bowl  |                    | 1968          |           |
| style="background:#fcc;" {{Sort Kansas City Chief                                                                                                                                            | s 01 [[1966                     | Kansas City C    | hiefs season       | Kansas Cit                                                                                                 | y Ch                                                                   | Super Bowl  |                    | 1969          |           |
| {{Sort Los Angeles Memorial Collseum 01 [[Los Ar                                                                                                                                             | igeles Memo                     | tag reflBoth [[] | ]]}}<br>os Angeles | Californiall                                                                                               | os Ai                                                                  | Super Bowl  |                    | 1970          |           |
| style="text-align: center;"  {{Sort 061946 61,946}}                                                                                                                                          |                                 |                  | 100 / Ingeleo, -   | oumonnalE                                                                                                  | 0074                                                                   | Super Down  | <u> </u>           | 1970          |           |
| style="text-align: center;"  <ref>{{Cite journal  last=</ref>                                                                                                                                | Maule  first=                   | -Tex  url=http:/ | //sportsillustra   | ated.cnn.cor                                                                                               | n/vai                                                                  | Super Bowl  | V                  | 1971          |           |
| -<br>  style="text-align: center:"  {{Sort[02][Super Bow]                                                                                                                                    |                                 | ring the AEL     | NEL morgor (       | As the Colts                                                                                               | mov                                                                    | Super Bowl  | VI                 | 1972          |           |
| {{Dts 1968 January 14}}                                                                                                                                                                      | U                               |                  | VI L Merger, P     |                                                                                                            | mov                                                                    | Super Bowl  | VII                | 1973          |           |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                                                                                             | ckers 02 [[19                   | ∂67 Green Bay    | / Packers sea      | ason Green                                                                                                 | Bay                                                                    | Super Bowl  | VIII               | 1974          |           |
| style="text-align: center;"  {{Sort 3314 33–14}}                                                                                                                                             |                                 |                  |                    | less d. D. et de s                                                                                         | - 11                                                                   | Super Bowl  | IX                 | 1975          |           |
| style= background:#icc;  {{Sort Oakland Raiders (                                                                                                                                            | J I [[[ 1967 Oa<br>ne Bowl]]]}} | akland Raiders   | season Oaki        | land Raider                                                                                                | s]] <s< td=""><td>Super Bowl</td><td>X</td><td>1976</td><th></th></s<> | Super Bowl  | X                  | 1976          |           |
| {{Sort Miami, Florida 01 [[Miami]], [[Florida]]{{#tag:                                                                                                                                       | ref [[Miami G                   | ∋ardens, Floriα  | da Miami Garo      | dens]] was i                                                                                               | ncor                                                                   | Super Bowl  |                    | 1077          |           |
| style="text-align: center;"  {{Sort 075546 75,546}}                                                                                                                                          |                                 |                  |                    |                                                                                                            |                                                                        | Super Bowl  |                    | 1977          |           |
| style="text-align: center;"  <ref>{{Cite journal  url=h</ref>                                                                                                                                | nttp://aol.spo                  | rtingnews.con    | n/nfl/story/200    | 08-01-15/su                                                                                                | per-k                                                                  | Super Bowl  | XII                | 1978          |           |
| -<br>  style="text-align: center:"  {{Sort[03][[Super Bow]]                                                                                                                                  |                                 |                  |                    |                                                                                                            |                                                                        | Super Bowl  | XIII               | 1979          |           |
| {{Dts  <mark>1969</mark>  January 12}}                                                                                                                                                       |                                 |                  |                    |                                                                                                            |                                                                        | Super Bowl  | XIV                | 1980          |           |
| style="background:#fcc;" {{Sort New York Jets 01                                                                                                                                             | [[1968 New                      | York Jets sea    | son New York       | < Jets]] <sup< td=""><td>&gt;^<!--;</td--><td>Super Bowl</td><td>XV</td><td>1981</td><th></th></td></sup<> | >^ ;</td <td>Super Bowl</td> <td>XV</td> <td>1981</td> <th></th>       | Super Bowl  | XV                 | 1981          |           |
| style="text-align: center;"  {{Sort 1607 16-7<br>  style="background:#d0e7ff;" /{Sort Indianapolis C                                                                                         | }}<br>olts:011[[196             | 8 Baltimore C    | olts season/B      | altimore Co                                                                                                | ltell<                                                                 | Super Bowl  | XVI                | 1982          |           |
| {{Sort Orange Bowl 02 Orange Bowl (2)}}                                                                                                                                                      |                                 | o Balanore of    |                    |                                                                                                            | 10]]                                                                   | Super Bowl  | XVII               | 1983          |           |
| {{Sort Miami, Florida 02 Miami, Florida (2) <ref grou<="" td=""><th>up=note nam</th><th>ne=b /&gt;}}</th><td></td><td></td><td></td><td>Super Bowl</td><td></td><td>1004</td><th></th></ref> | up=note nam                     | ne=b />}}        |                    |                                                                                                            |                                                                        | Super Bowl  |                    | 1004          |           |
| style="text-align: center;"  {{Sort 075389 75,389}}                                                                                                                                          | tto://www.or                    | oortingnowo o    | om/orobivoo/o      | uporbowl/2                                                                                                 | html                                                                   | Super Bowl  |                    | 1964          |           |
| <pre><includeonlv>l}</includeonlv></pre>                                                                                                                                                     | nup.//www.sp                    | Jon ingriews.co  | JIII/archives/s    | superbowi/3.                                                                                               | .riurii                                                                | Super Bowl  | XIX                | 1985          |           |
| -                                                                                                                                                                                            | _                               |                  |                    |                                                                                                            |                                                                        | Super Bowl  | XX                 | 1986          |           |
| style="text-align: center;"  {{Sort 04 [[Super Bowl I                                                                                                                                        | <mark>∨</mark>   V]]}}          |                  |                    |                                                                                                            |                                                                        | Super Bowl  | XXI                | 1987          |           |
| {{Dts  <mark>1970</mark>  January 11}}                                                                                                                                                       |                                 |                  |                    |                                                                                                            |                                                                        | Super Bowl  | XXII               | 1988          |           |

| <b>PROSE Playground</b> Program Synthesis using Examples SDK                                                                                                                                      | Add file                                                                                                                                                 | Reset          | ←<br>Undo        | →<br>Redo                                                                                                    | Learn                                                                    | Settings    | Result         |            | PROSE SDK<br>About |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------|----------------|------------|--------------------|
|                                                                                                                                                                                                   | 1                                                                                                                                                        |                |                  |                                                                                                              |                                                                          | Output      | Program vie    | ewer Disam | biguation          |
| BlueLabel GreenLabel YellowLabel OrangeLabel                                                                                                                                                      |                                                                                                                                                          |                |                  |                                                                                                              |                                                                          | 49 rows 3 c | olumns         |            |                    |
| style="text-align: center;"  {{Sort 01 [Super Bowl ]                                                                                                                                              | I]]}}                                                                                                                                                    |                |                  |                                                                                                              |                                                                          | BlueLab     | el Gre         | enLabel    | YellowLabel        |
| {{Dts <u>1967</u> January 15}}<br>  style="background:#d0e7ff:" //Sort/Green Bay Pac                                                                                                              | kors 011111                                                                                                                                              | 66 Green Ba    | v Packers se     | asonlGreen                                                                                                   | Bay                                                                      | Super Bowl  | l 1967         |            | 35-10              |
| style="text-align: center;"  {{Sort 3510 <mark>35–10</mark> }                                                                                                                                     |                                                                                                                                                          | oo Green ba    | y i donero oca   | asonjoreen                                                                                                   | Day                                                                      | Super Bowl  | II 1968        |            |                    |
| style="background:#fcc;" {{Sort Kansas City Chiefs                                                                                                                                                | 3 01 [[1966 /                                                                                                                                            | Kansas City C  | chiefs season    | l∣Kansas Cit                                                                                                 | ty Ch                                                                    | Super Bowl  | 1960           |            |                    |
| {{Sort Los Angeles Memorial Coliseum 01 [[Los An                                                                                                                                                  | geles Memo                                                                                                                                               | orial Coliseum | I]]}}            | Californiall                                                                                                 | 08 1                                                                     | Super Dowl  | 1909           |            |                    |
| style="text-align: center;"  {{Sort[061946]61,946}}                                                                                                                                               | Informajjj                                                                                                                                               |                | LUS Angeles,     | Camornia                                                                                                     | .05 A                                                                    | Super Bowl  | 1970           |            |                    |
| style="text-align: center;"  <ref>{{Cite journal  last=l</ref>                                                                                                                                    | Maule  first=                                                                                                                                            | Tex  url=http: | //sportsillustra | ated.cnn.co                                                                                                  | m/vai                                                                    | Super Bowl  | V <u>19/1</u>  |            |                    |
| -                                                                                                                                                                                                 |                                                                                                                                                          | ring the AE    |                  | As the Calt                                                                                                  |                                                                          | Super Bowl  | VI <u>1972</u> |            |                    |
| {{Dtsl <mark>1968</mark>  January 14}}                                                                                                                                                            | 11]]}} Du</th <th>ining the AFL-</th> <th>NFL merger,</th> <th>As the Colt</th> <td>STION</td> <td>Super Bowl</td> <td>VII 1973</td> <td></td> <th></th> | ining the AFL- | NFL merger,      | As the Colt                                                                                                  | STION                                                                    | Super Bowl  | VII 1973       |            |                    |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                                                                                                  | kers 02 [[19                                                                                                                                             | 67 Green Ba    | y Packers sea    | ason Green                                                                                                   | Bay                                                                      | Super Bowl  | VIII 1974      |            |                    |
| style="text-align: center;"  {{Sort 3314 33–14}}                                                                                                                                                  |                                                                                                                                                          |                |                  |                                                                                                              | 11 .                                                                     | Super Bowl  | IX 1975        |            |                    |
| style="background:#fcc;" {{Sort Oakland Raiders 0                                                                                                                                                 | 1 [[1967 Oa                                                                                                                                              | akland Raiders | s season Oak     | kland Raide                                                                                                  | rsjj <s< td=""><td>Super Bowl</td><td>X 1976</td><td></td><th></th></s<> | Super Bowl  | X 1976         |            |                    |
| {{Sort Miami, Florida 01 [[Miami]], [[Florida]]{{#tag:r                                                                                                                                           | ef [[Miami G                                                                                                                                             | Gardens, Flori | da Miami Gar     | dens]] was                                                                                                   | incor                                                                    | Super Bowl  | VI 1077        |            |                    |
| style="text-align: center;"  {{Sort 075546 75,546}}                                                                                                                                               |                                                                                                                                                          |                |                  |                                                                                                              |                                                                          | Super Bowl  | <u> 1977</u>   |            |                    |
| style="text-align: center;"  <ref>{{Cite journal  url=h</ref>                                                                                                                                     | ttp://aol.spo                                                                                                                                            | ortingnews.cor | n/nfl/story/20   | 08-01-15/sı                                                                                                  | iper-k                                                                   | Super Bowl  | XII 1978       |            |                    |
| -<br>  style="text-align: center;"  {{Sort 03 [[Super Bowl II                                                                                                                                     | ]]}}                                                                                                                                                     |                |                  |                                                                                                              |                                                                          | Super Bowl  | XIII 1979      |            |                    |
| {{Dts  <mark>1969</mark>  January 12}}                                                                                                                                                            | 1000 CTTT                                                                                                                                                |                |                  |                                                                                                              |                                                                          | Super Bowl  | XIV 1980       |            |                    |
| style="background:#fcc;" {{Sort New York Jets 01 [                                                                                                                                                | [1968 New                                                                                                                                                | York Jets sea  | son New Yor      | k Jets]] <sup< th=""><td>)&gt;^<!--;</td--><td>Super Bowl</td><td>XV 1981</td><td></td><th></th></td></sup<> | )>^ ;</td <td>Super Bowl</td> <td>XV 1981</td> <td></td> <th></th>       | Super Bowl  | XV 1981        |            |                    |
| style="text-align: center;"   {{Sort 1607 16-7&ndsp}<br>  style="background:#d0e7ff:" {{Sort Indianapolis Co                                                                                      | }<br>sits:01 [[196                                                                                                                                       | 8 Baltimore C  | olts seasonlF    | Baltimore Co                                                                                                 | olts]]<                                                                  | Super Bowl  | XVI 1982       |            |                    |
| {{Sort Orange Bowl 02 Orange Bowl (2)}}                                                                                                                                                           |                                                                                                                                                          | - 2010101010   |                  |                                                                                                              | 511011                                                                   | Super Bowl  | XVII 1983      |            |                    |
| {{Sort Miami, Florida 02 Miami, Florida (2) <ref grou<="" td=""><th>p=note nam</th><th>ne=b /&gt;}}</th><th></th><th></th><td></td><td>Super Bowl</td><td>XVIII 1094</td><td></td><th></th></ref> | p=note nam                                                                                                                                               | ne=b />}}      |                  |                                                                                                              |                                                                          | Super Bowl  | XVIII 1094     |            |                    |
| style="text-align: center;"  {{Sort 0/5389 /5,389}}                                                                                                                                               | ttp://www.ex                                                                                                                                             | ortingnows o   | om/archives/     | superbowl/3                                                                                                  | html                                                                     | Super Bowl  | <u> </u>       |            |                    |
| <pre><includeonly>{/includeonly&gt;</includeonly></pre>                                                                                                                                           | .up.//www.sp                                                                                                                                             | bortingnews.c  |                  | superbown                                                                                                    |                                                                          | Super Bowl  | XIX 1985       |            |                    |
| -                                                                                                                                                                                                 |                                                                                                                                                          |                |                  |                                                                                                              |                                                                          | Super Bowl  | XX 1986        |            |                    |
| style="text-align: center;"  {{Sort 04 [[Super Bowl I]                                                                                                                                            | <mark>/</mark> ∥IV]]}}                                                                                                                                   |                |                  |                                                                                                              |                                                                          | Super Bowl  | XXI 1987       |            |                    |
|                                                                                                                                                                                                   |                                                                                                                                                          |                |                  |                                                                                                              |                                                                          | Super Bowl  | XXII 1988      |            |                    |

| <b>PROSE Playground</b><br>Program Synthesis using Examples SDK                                                        | Add file                                                                                                                                                      | Reset         | <b>←</b><br>Undo            | →<br>Redo    | C                                                                                                                       | Settings    | Resu    | lt       | PROSE<br>Ał                              | SDK<br>bout |
|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------|-------------|---------|----------|------------------------------------------|-------------|
|                                                                                                                        | 3                                                                                                                                                             |               |                             |              |                                                                                                                         | Output      | Prograi | n viewer | Disambiguation                           |             |
| BlueLabel GreenLabel YellowLabel OrangeLabel                                                                           |                                                                                                                                                               |               |                             |              |                                                                                                                         | 49 rows 3 d | columns |          |                                          |             |
| style="text-align: center;"  {{Sort 01 [Super Bowl I                                                                   | ]]}}                                                                                                                                                          |               |                             |              |                                                                                                                         | BlueLab     | el      | GreenLab | el YellowLabel                           | <u>^</u>    |
| {{Dis <mark>1967</mark> January 15}}<br>  style="background:#d0e7ff:" {{Sort Green Bay Page                            | ckers 01I[[1]                                                                                                                                                 | 966 Green     | Bav Packers sea             | asonlGreen   | Bay                                                                                                                     | Super Bow   | LI 19   | 67       | 35-10                                    |             |
| style="text-align: center;"  {{Sort 3510 <mark>35–10</mark> }                                                          |                                                                                                                                                               |               |                             |              |                                                                                                                         | Super Bow   | L II 19 | 68       | 33-14                                    |             |
| style="background:#fcc;" {{Sort Kansas City Chief                                                                      | s 01 [[1966                                                                                                                                                   | Kansas Cit    | y Chiefs season             | Kansas Cit   | y Ch                                                                                                                    | · ·         |         |          | 16-7 :}}                                 |             |
| {{Sort Los Angeles Memorial Collseum 01 [[Los Ar<br> {{Sort Pasadena, California 01 [[] os Angeles]], [[C              | igeles iviem<br>alifornia]]{{#                                                                                                                                | tag:reflBoth  | umjj}}<br>n [[] os Angeles. | Californiall | os A                                                                                                                    |             |         |          | style="backgrour                         | nd:         |
| style="text-align: center;"  {{Sort 061946 61,946}}                                                                    |                                                                                                                                                               |               | . [[_00 /go.oo,             |              |                                                                                                                         |             |         |          | {{Sort Indianapo                         | olis        |
| style="text-align: center;"  <ref>{{Cite journal  last=</ref>                                                          | Maule  first                                                                                                                                                  | =Tex  url=h   | ttp://sportsillustra        | ated.cnn.co  | m/vai                                                                                                                   |             |         |          | Colts 01 [[1968                          |             |
| -<br>  style="text-align: center:"  {{Sort[02][ <mark> Super Bow  ]</mark>                                             | ]]}} Di</th <th>uring the AF</th> <th>I-NFL merger</th> <td>As the Colts</td> <td>s mov</td> <td></td> <td></td> <td></td> <td>Baltimore Colts</td> <td></td> | uring the AF  | I-NFL merger                | As the Colts | s mov                                                                                                                   |             |         |          | Baltimore Colts                          |             |
| {{Dts  <mark>1968</mark>  January 14}}                                                                                 |                                                                                                                                                               | annig are / a |                             |              | 1                                                                                                                       |             |         |          | season   Baltimore                       | е           |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                       | ckers 02 [[1                                                                                                                                                  | 967 Green     | Bay Packers sea             | ason Green   | Bay                                                                                                                     |             |         |          | Colts]]                                  |             |
| style="text-align: center;"  {{Sort 3314  <mark>33–14</mark> }}<br>  style="background:#fcc:" {{Sort Oakland Baiders ( | )1/[[1967 ()                                                                                                                                                  | akland Raid   | ters seasonlOak             | land Raide   | rell <e< td=""><td>Super Bow</td><td>101 10</td><td>69</td><td><sup>+</sup>}}  <br/>{{Sort Orange Bo</td><td></td></e<> | Super Bow   | 101 10  | 69       | <sup>+</sup> }}  <br>{{Sort Orange Bo    |             |
| {{Sort Orange Bowl 01 [[Miami Orange Bowl Orang                                                                        | ge Bowl]]}}                                                                                                                                                   |               |                             |              | 13]] -3                                                                                                                 | Super Down  |         | 07       | 021Orange Bowl                           | (2)33       |
| {{Sort Miami, Florida 01 [[Miami]], [[Florida]]{{#tag:                                                                 | ref [[Miami (                                                                                                                                                 | Gardens, Fl   | orida Miami Gar             | dens]] was   | incor                                                                                                                   |             |         |          | {{Sort Miami,                            | (-/))       |
| style="text-align: center;"  {{Sort 0/5546 /5,546}}                                                                    | ttn://aol.sn                                                                                                                                                  | ortingnews    | com/nfl/story/201           | 08-01-15/0   | iner-t                                                                                                                  |             |         |          | Florida 02 Miam                          | i,          |
|                                                                                                                        | ntp.//a01.5pt                                                                                                                                                 | Julighews.    | com/m/story/200             | 00-01-10/30  | ipei-r                                                                                                                  |             |         |          | Florida (2) <ref< td=""><td></td></ref<> |             |
| style="text-align: center;"  {{Sort 03 [ <mark>Super Bowl I</mark>                                                     | <mark>  </mark>    ]]}}                                                                                                                                       |               |                             |              |                                                                                                                         |             |         |          | group=note name                          | e=b         |
| {{Dts   <u>1969</u>  January 12}}<br>  style="background:#fee:" {{Sert New York, lete 01                               | [[1068 Now                                                                                                                                                    | Vork lote a   | SocoolNow Vor               | k lotellcour | SA-1                                                                                                                    |             |         |          | />}}   style="tex                        | .t-         |
| style="text-align: center;"  {{Sort 1607 16-7                                                                          | 1900 New<br>}}                                                                                                                                                | TOIK JELS S   | seasoninew ron              | k perell-ent | )                                                                                                                       |             |         |          | align: center;"                          | (F )        |
| style="background:#d0e7ff;" {{Sort Indianapolis C                                                                      | olts 01 [[196                                                                                                                                                 | 88 Baltimore  | e Colts season E            | Baltimore Co | olts]]<                                                                                                                 |             |         |          | {{SOLL 0/2389 /:                         | 5,5         |
| {{Sort Orange Bowl 02 Orange Bowl (2)}}                                                                                | in-noto nor                                                                                                                                                   | no-h />11     |                             |              |                                                                                                                         |             |         |          | 23-7 }}                                  |             |
| {{Sort[075389]75.389}}                                                                                                 | ip-note nar                                                                                                                                                   |               |                             |              | 1                                                                                                                       |             |         |          | style= backgrour                         | 10:         |
| style="text-align: center;"  <ref>{{Cite journal  url=h</ref>                                                          | nttp://www.s                                                                                                                                                  | portingnew    | s.com/archives/s            | superbowl/3  | .html                                                                                                                   |             |         |          | Vikings 01   [[196                       | 9           |
| <includeonly> }</includeonly>                                                                                          |                                                                                                                                                               |               |                             |              |                                                                                                                         |             |         |          | Minnesota Viking                         | 2S          |
| -<br>    style="text-align: center:"  {{Sort 04 [ <mark> Super Bow   </mark>                                           | VIIV11}}                                                                                                                                                      |               |                             |              |                                                                                                                         |             |         |          | season   Minnesot                        | ía 🛛        |
| {{Dts  <mark>1970</mark>  January 11}}                                                                                 |                                                                                                                                                               |               |                             |              | 1. A.                                                                               |             |         |          | Vikings]]                                |             |
|                                                                                                                        |                                                                                                                                                               |               |                             |              |                                                                                                                         |             |         |          | . /                                      | c           |



| <b>PROSE Playground</b> Program Synthesis using Examples SDK                                                                | Add file                                                                                                                                                   | Reset           | ←<br>Undo             | →<br>Redo    | Learn                                                                         | <b>S</b> ettings | <b>↓</b><br>Result | PROSE SDK<br>About  |  |
|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|--------------|-------------------------------------------------------------------------------|------------------|--------------------|---------------------|--|
|                                                                                                                             | J                                                                                                                                                          |                 |                       |              |                                                                               | Output           | Program view       | wer Disambiguation  |  |
| BlueLabel GreenLabel YellowLabel OrangeLabel                                                                                |                                                                                                                                                            |                 |                       |              |                                                                               | 49 rows 3 c      | olumns             |                     |  |
| style="text-align: center;"  {{Sort 01 [Super Bowl                                                                          | 1]]}}                                                                                                                                                      |                 |                       |              |                                                                               | BlueLab          | el Gree            | enLabel YellowLabel |  |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                            | kers 01 [[1{                                                                                                                                               | 966 Green Ba    | v Packers sea         | ason Green   | Bay                                                                           | Super Bowl       | l 1967             | 35-10               |  |
| style="text-align: center;"  {{Sort 3510 <mark>35–10</mark> }}                                                              |                                                                                                                                                            |                 | ,                     |              |                                                                               | Super Bowl       | ll 1968            | 33-14               |  |
| style="background:#fcc;" {{Sort Kansas City Chiefs                                                                          | 301 [[1966                                                                                                                                                 | Kansas City (   | Chiefs season         | I Kansas Cil | ty Ch                                                                         | Super Bowl       | 1969               | 16-7                |  |
| {{Sort Los Angeles Memorial Collseum 01 [[Los An                                                                            | geles iviemo<br>alifornia]]{{#                                                                                                                             | tad:reflBoth [] | 1]]}}<br>Los Angeles. | Californiall | os A                                                                          | Super Bowl       | IV 1970            | 23-7                |  |
| style="text-align: center;"  {{Sort 061946 61,946}}                                                                         |                                                                                                                                                            |                 | ,,                    |              |                                                                               | Super Bowl       | V 1071             |                     |  |
| style="text-align: center;"  <ref>{{Cite journal  last=</ref>                                                               | Vaule  first=                                                                                                                                              | Tex  url=http:  | //sportsillustra      | ated.cnn.co  | m/vai                                                                         | Super Bowl       | V 1771             |                     |  |
| -<br>  style="text-align: center:"  {{Sort 02 [Super Bowl ]]                                                                | ]]}} Du</td <th>urina the AFL-</th> <td>NFL merger.</td> <th>As the Colts</th> <td>s mov</td> <td>Super Bowl</td> <td>VI 1972</td> <td>24-3</td> <td></td> | urina the AFL-  | NFL merger.           | As the Colts | s mov                                                                         | Super Bowl       | VI 1972            | 24-3                |  |
| {{Dts  <mark>1968</mark>  January 14}}                                                                                      |                                                                                                                                                            | ing alora L     | Letter ger,           |              |                                                                               | Super Bowl       | VII <u>1973</u>    | 14-7                |  |
| style="background:#d0e7ff;" {{Sort Green Bay Pac                                                                            | kers 02 [[19                                                                                                                                               | 967 Green Ba    | y Packers sea         | ason Green   | Bay                                                                           | Super Bowl       | VIII 1974          | 24-7                |  |
| style="text-align: center;"  {{Sort 3314 33–14}}<br>  style="background:#fcc:" {{Sort Oakland Baiders 0                     | 11[[1967 0:                                                                                                                                                | akland Raider   | s seasonlOak          | dand Raide   | rell <e< td=""><td>Super Bowl</td><td>IX 1975</td><td>16-6</td><td></td></e<> | Super Bowl       | IX 1975            | 16-6                |  |
| {{Sort Orange Bowl 01 [[Miami Orange Bowl Orang                                                                             | e Bowl]]}}                                                                                                                                                 |                 | 5 5045011041          |              | 10]] 40                                                                       | Super Bowl       | X 1976             | 21-17               |  |
| {{Sort Miami, Florida 01 [[Miami]], [[Florida]]{{#tag:r                                                                     | ef [[Miami G                                                                                                                                               | Gardens, Flori  | da Miami Gar          | dens]] was   | incor                                                                         | Super Bowl       | XI 1977            | 32-14               |  |
| style="text-align: center;"  {{Sort 0/5546 /5,546}}                                                                         | ttn://aol.snc                                                                                                                                              | ortinanews co   | m/nfl/story/20        | 08-01-15/9   | iner-t                                                                        | Super Bowl       | XII 1978           | 27-10               |  |
| -                                                                                                                           |                                                                                                                                                            | in ingriews.com | 11/111/3tory/20       | 00 01 10/00  |                                                                               | Super Bowl       | VIII 1070          | 25 21               |  |
| style="text-align: center;"  {{Sort 03 [[Super Bowl II                                                                      | ]]}}                                                                                                                                                       |                 |                       |              |                                                                               | Super Bowl       | <u>XIII</u> 1777   |                     |  |
| {{Dts  1969 January 12}}<br>  style="background:#fee:"!!/{Sort!New York, lets 01!!                                          | 11068 Now                                                                                                                                                  | Vork late cor   | sonNow Vor            | k lotellceur | >A </td <td>Super Bowl</td> <td>XIV 1980</td> <td>31-19</td> <td></td>        | Super Bowl       | XIV 1980           | 31-19               |  |
| style="text-align: center;"  {{Sort 1607 16-7 }                                                                             | [1900 New ]                                                                                                                                                | TOIN JELS SEA   | sonninew ton          | k Jeis]]~sup | )>*~/;                                                                        | Super Bowl       | XV 1981            | 27-10               |  |
| style="background:#d0e7ff;" {{Sort Indianapolis Co                                                                          | ,<br>lts 01 [[196                                                                                                                                          | 8 Baltimore C   | olts season E         | Baltimore Co | olts]]<                                                                       | Super Bowl       | XVI 1982           | 26-21               |  |
| {{Sort Orange Bowl 02 Orange Bowl (2)}}                                                                                     | n=noto non                                                                                                                                                 | aa-b (>))       |                       |              |                                                                               | Super Bowl       | XVII 1983          | 27-17               |  |
| {{Sort  v  ami, Florida 02  v  ami, Florida (2) <ref grou<br="">  style="text-align: center:"  {{Sort 075389 75.389}}</ref> | p=note nam                                                                                                                                                 | ne=b />}}       |                       |              |                                                                               | Super Bowl       | XVIII 1984         | 38-9                |  |
| style="text-align: center;"  <ref>{{Cite journal  url=h</ref>                                                               | ttp://www.sr                                                                                                                                               | portingnews.c   | om/archives/s         | superbowl/3  | 3.html                                                                        | Super Bowl       | XIX 1985           | 38-16               |  |
| <includeonly> }</includeonly>                                                                                               |                                                                                                                                                            |                 |                       |              |                                                                               | Super Bowl       | XX 1986            | 46-10               |  |
| -<br>  style="text-align: center:"  {{Sort[04][[Super Bowl I]                                                               | /11//11}}                                                                                                                                                  |                 |                       |              |                                                                               | Super Bowd       | VVI 1097           | 30.20               |  |
| {{Dts  <mark>1970</mark>  January 11}}                                                                                      | 1111 - • • •                                                                                                                                               |                 |                       |              |                                                                               |                  | AAI 170/           |                     |  |
|                                                                                                                             |                                                                                                                                                            |                 |                       |              |                                                                               | Super Bowl       | XXII 1988          | 42-10               |  |

### **Table Extraction**



#### From various kinds of semi-structured documents.

- Text files \_\_\_\_\_\_ [PLDI '14, Le & Gulwani]
- Webpages [SIGMOD '20, Raza & Gulwani]
- PDF [ICPR '20, Zhang et al.]
- Semi-structured spreadsheets [PLDI '15, Barowy et al.]
- Mixed formats [OOPSLA '20, Gulwani et al]

*"Text by example is freaking awesome... crying and clapping"* 

*"Web by example is the best thing since sliced virtual network architectures over 5G"* 

https://aka.ms/prose-table-extraction



|{{Dts|1970|January|11}}

#### Automating active learning as Analogical Reasoning

ES: "35-10", "33-14" USER Thats correct. Very impressive indeed! style="text-align: center;" {{Sort[03][[Super Bowl III]]]}} Why did you not get confused and pick nuary 12} strings like "08-25" or "01-12"? round:#fcc;"|{{Sort|New York Jets 01|[[1968 New York Jets brk Jets]]<sup>^</sup>}} lign: center;"| {{Sort|1607(16-7 }} ASSISTANT Thank you! I didn't get confused and pick round:#d0e7ff;"|{{Sort|Indianapolis Colts 01|[[1968 Baltimore strings like "08-25" or "01-12" because Baltimore Colts]]<sup>t</sup>}} those strings are part of dates in the Bowl 02 Orange Bowl (2)} format YYYY-MM-DD or MM-DD, which are Florida 02|Miami, Florida (2)<ref group=note name=b />}} not similar to the examples you provided. lign: center;"| {{Sort|075389|75,389}} The examples "35-10" and "33-14" are lign: center;"|<ref>{{Cite journal both in the format of two numbers w.sportingnews.com/archives/superbowl/3.html |title=Super Bowl separated by a hyphen, which is more ay Joe Show |accessdate=2009(08-25)date=1969(01-12)journal= similar to a sports score like "16-7". My vs]]}}</ref> <includeonly>|}</includeonly></onlyinclude>|algorithm is designed to recognize g in the TEXT that is most similar to the EXAMPLES is: patterns and find the most similar string based on the examples given.

#### Flash Fill for Repeated Edits in Code

```
var temp = (GetTemp() - 32) * (5 / 9);
Conversions.FtoC(GetTemp());
```

```
double MaxTempInC(double[] fTemps) {
 return (fTemps.Max() - 32) * (5 / 9);
 Conversions.FtoC(fTemps.Max());
...
```

```
double MinTempInC(double[] fTemps) {
 var m = fTemps.Min();
 return (m - 32) * (5 / 9);
 Conversions.FtoC(m);
}
```

[ICSE '17, Rolim et al., Learning Syntactic Program Transformations from Examples]



{ name: Jerry } 🖖 😎 @jerrynixon · Apr 19 The new IntelliCode engine in @VisualStudio. Almost spooky. @amandaksilver



Alistair Evans @evocationist

I'm in the middle of changing a load of Memory<byte> and Span<byte> to their ReadOnly variant, and the new @VisualStudio intellicode feature knows what I'm doing and starts suggesting the change to ReadOnly in the right places, which is pretty wild.



David Pine A @davidpine7 · 22 m Wow, this whole #IntelliCode thing is crazy cool.



VISUAL STUDIC

@VisualStudio : The Al-based model was able to detect that I was updating some of the iterations to order by their name, and then it said - "Hey, this is what you're looking for, right?!".

#### Me : Yes, please... 🧐 #dotnet







3:43

Jochem Bonarius @BonariusJochem

@MarkPavWT I almost felt a tear coming when #intellicode automatically suggested to make many many repetative changes in the code I'd otherwise had to do by hand. It's amazing! Thank you!

2:38 AM · Mar 30, 2021 · Twitter for Android

...

This new aggressive #IntelliCode automatic code changing based on previous actions<sup>™</sup> sometimes gives me a heart attack because it happens so suddenly. (This is a compliment btw, it's awesome).



Sam Afshari 😳 @samafshari · 1 m

Als antwoord op @pgroene

You should put a "boing!" sound effect for every time it happens 🤣

Hold my beer, I need to create the VSIX for it!





MORE VIDEOS

### **Semantic Repeated Edits**

try { ts = ... }

Catch (Exception ex)

info.ReportClientError("Scheme is missing");

info.ReportClientError("Scheme is missing",System.Net.HttpStatusCode.BadRequest);

return;

{

Default:

info.ReportClientError("No such action");

info.ReportClientError("No such action",System.Net.HttpStatusCode.NotFound);

return;



{

}

### Semantic Repeated Edits using Spatial Context

try { ts = ... }

Catch (Exception ex)

info.ReportClientError("Scheme is missing",System.Net.HttpStatusCode.BadRequest);
return;

Default:

info.ReportClientError("No such action", );
return;



{

### Semantic Repeated Edits using Spatial Context

try { ts = ... }

Catch (Exception ex)

info.ReportClientError("Scheme is missing",System.Net.HttpStatusCode.BadRequest);
return;

Default:

info.ReportClientError("No such action",System.Net.HttpStatusCode.BadRequest);
return;



# Semantic Repeated Edits as Analogical Reasoning

USERInput: "scheme is missing"Output: System.Net.HttpStatusCode.BadRequest

Input: "no such action" Output:

ASSISTANT System.Net.HttpStatusCode.NotFound



### Semantic Repeated Edits using Temporal Context

try { ts = ... }

Catch (Exception ex)

info.ReportClientError("Scheme is missing");-

info.ReportClientError("Scheme is missing",System.Net.HttpStatusCode.BadRequest);

return;

{

Default:

```
info.ReportClientError("No such action",);
return;
```



### Semantic Repeated Edits using Temporal Context

try { ts = ... }

Catch (Exception ex)

info.ReportClientError("Scheme is missing");

info.ReportClientError("Scheme is missing",System.Net.HttpStatusCode.BadRequest);

return;

{

Default:

info.ReportClientError("No such action",System.Net.HttpStatusCode.NotFound);
return;



### **Associated Edits**

```
using System;
```

```
using NUnit.Framework;
```

```
public class TimeConfigurationTests : NLogTestBase
```

```
using XUnit;
```

```
public class TimeConfigurationTests : NLogTestBase, IDisposable
```

```
[TearDown] public void TearDown(){ ... }
```

```
public void Dispose() { ... }
```

[<del>Test]</del>

{

[Fact]

```
public void DefaultTimeSourceTest{ ... }
```



### Associated Edits using Spatial Context

using System;

using NUnit.Framework;

```
public class TimeConfigurationTests : NLogTestBase
```

public void Dispose(){ ... }

[Fact]

```
public void DefaultTimeSourceTest{ ... }
```



### Associated Edits using Spatial Context

using System;

using NUnit.Framework;

public class TimeConfigurationTests : NLogTestBase

using NUnit.Framework;

public class TimeConfigurationTests : NLogTestBase

```
public void Dispose(){ ... }
```

[Fact]

```
public void DefaultTimeSourceTest{ ... }
```



### Associated Edits using Temporal Context

using System;

using NUnit.Framework;

public class TimeConfigurationTests : NLogTestBase

[TearDown] public void TearDown(){ ... }

public void Dispose(){ ... }

[Test]

[<del>Fact]</del>

```
public void DefaultTimeSourceTest{ ... }
```



### Associated Edits using Temporal Context

using System;

using NUnit.Framework;

public class TimeConfigurationTests : NLogTestBase

using XUnit;

public class TimeConfigurationTests : NLogTestBase, IDisposable

```
[TearDown] public void TearDown(){ ... }
```

```
public void Dispose(){ ... }
```

[Test]

[Fact]

```
public void DefaultTimeSourceTest{ ... }
```



### Associated Edits as Analogical Reasoning

| U | S | E | R |  |
|---|---|---|---|--|
|---|---|---|---|--|

Input: [TearDown] public void TearDown() Output: public void Dispose()

Input: [Test] Output: [Fact]

Input: using NUnit.Framework Output: USER

Input: [TearDown] public void TearDown() Output: public void Dispose()

Input: [Test] Output: [Fact]

Input: public class TimeConfigurationTests: NLogTestBase Output:

ASSISTANT public class TimeConfigurationTests : NLogTestBase, IDisposable

ASSISTANT using Xunit

### Thanks to PROSE Team (aka.ms/prose)



Anna Fariha



**Chris Parnin** 

Ivan Radicek



Vu Le



**Danny Simmons** 

**Mukul Singh** 



Priyan Vaithilingam



Alex Polozov



**Daniel Perelman** 



José Cambronero

**Austin Henley** 









Priyanshu Gupta





Arjun Radhakrishna



Gust Verbruggen



Ashish Tiwari



**Gustavo Soares** 

**Rishabh Singh** 



Mohammad Raza



Chethan M





Yasharth Bajpai



**Dan Morris** 



Harshit Joshi



Anjali Singh



# Analogical Reasoning is an emergent capability of LLMs!



It can enhance Programmingby-example (PBE) experiences.

- Synthesis from fewer examples.
- Explanation generation
- Semantic transformations

Ways to Improves LLM performance

- Phrasing a problem as analogical reasoning works better.
- Various methods from PBE can improve LLM performance.

