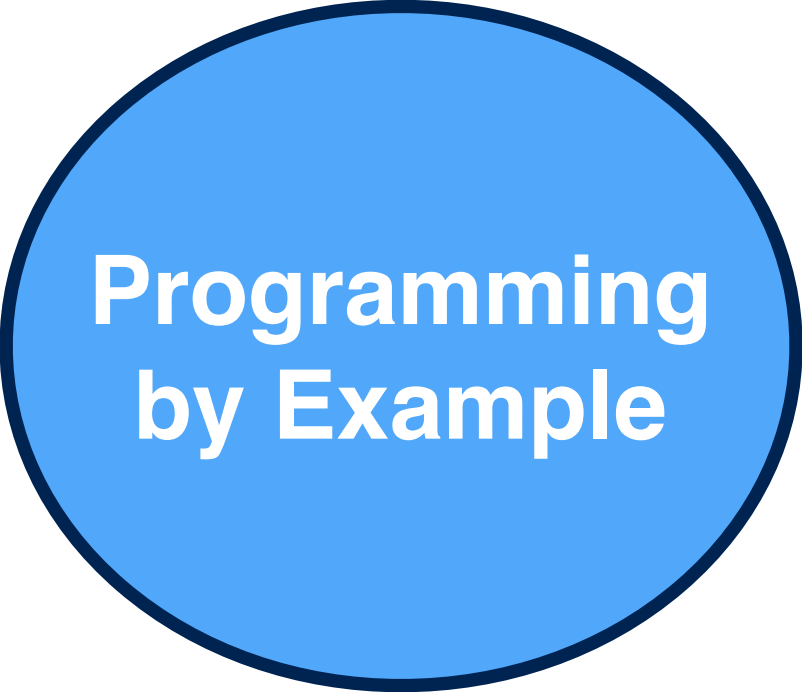


CSCI-5535 Final Project

Programming by Example and its Application

Ryo Suzuki

PhD in Human-Computer Interaction Group



**Programming
by Example**



Program Synthesis

The diagram consists of two concentric circles. The outer circle is light gray with a dark gray border and contains the text 'Program Synthesis'. The inner circle is blue with a dark blue border and contains the text 'Programming by Example'. The inner circle is positioned in the lower-left quadrant of the outer circle, indicating that programming by example is a specific instance or subset of the broader field of program synthesis.

**Programming
by Example**

Program Synthesis

Program Synthesis

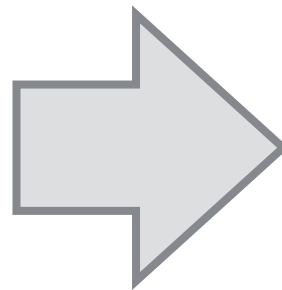
*“Program Synthesis is the task of **discovering a program** from **user intent** expressed in some constraints.”*

[“Dimensions in Program Synthesis”, Gulwani, 2010]

Program Synthesis

*“Program Synthesis is the task of **discovering a program** from **user intent** expressed in some constraints.”*

[“Dimensions in Program Synthesis”, Gulwani, 2010]



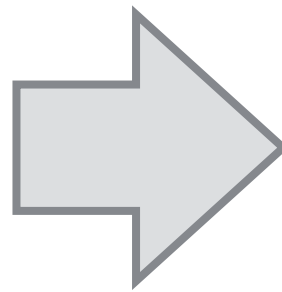
User Intent

Natural language

Demonstration

Logical relation

Input output examples



User Intent

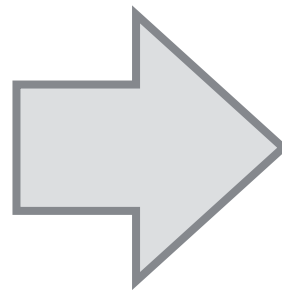
Natural language

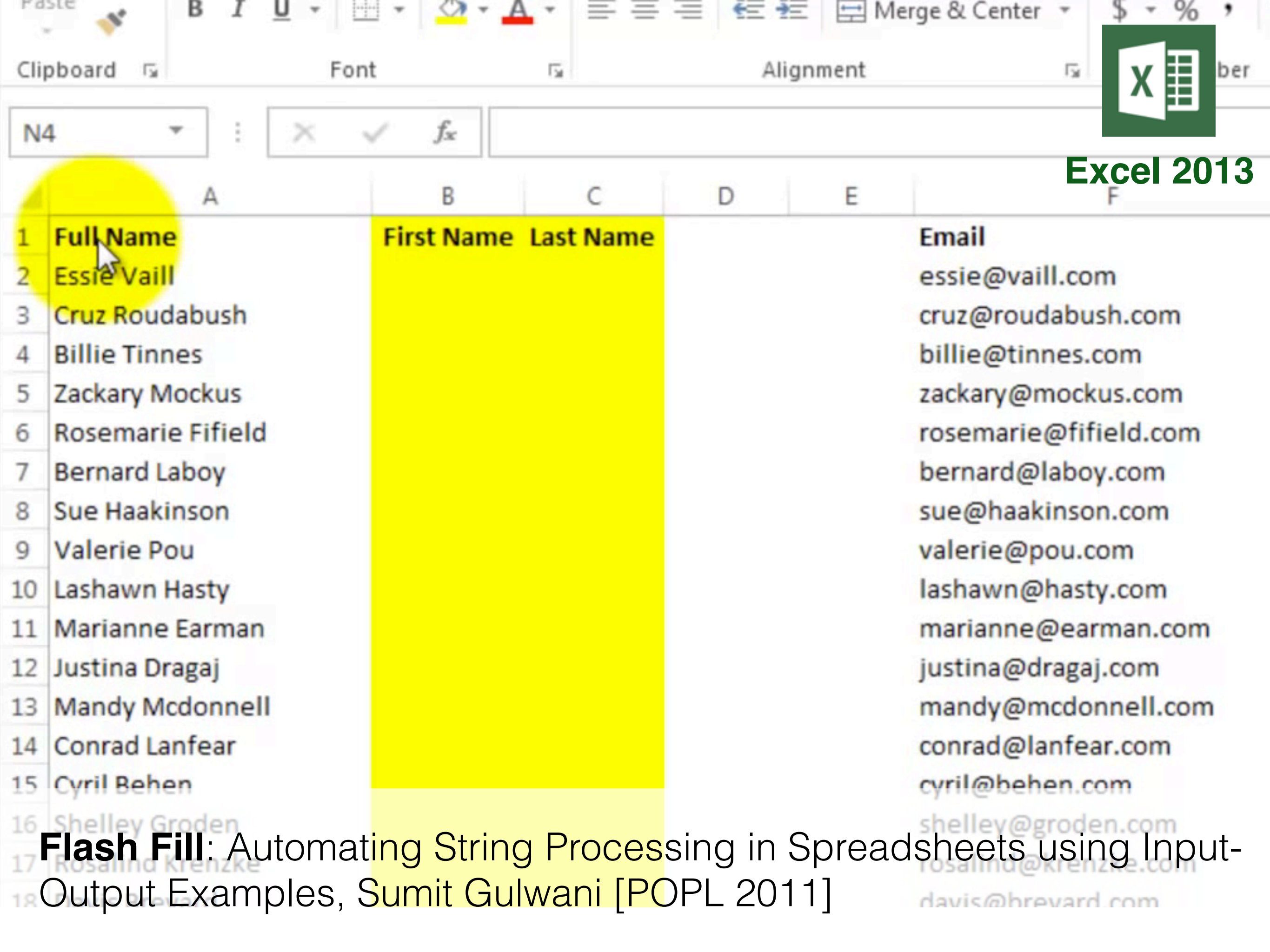
Demonstration

Logical relation

Input output examples

**Programming
by Example**





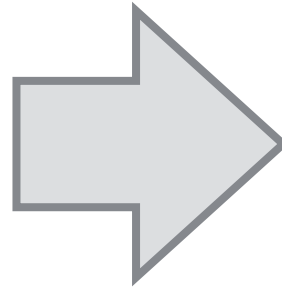
Excel 2013

N4

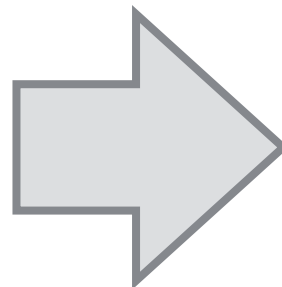
X ✓ *fx*

| | A | B | C | D | E | F |
|----|-------------------|------------|-----------|---|---|-----------------------|
| 1 | Full Name | First Name | Last Name | | | Email |
| 2 | Essie Vaill | | | | | essie@vaill.com |
| 3 | Cruz Roudabush | | | | | cruz@roudabush.com |
| 4 | Billie Tinnes | | | | | billie@tinnes.com |
| 5 | Zackary Mockus | | | | | zackary@mockus.com |
| 6 | Rosemarie Fifield | | | | | rosemarie@fifield.com |
| 7 | Bernard Laboy | | | | | bernard@laboy.com |
| 8 | Sue Haakinson | | | | | sue@haakinson.com |
| 9 | Valerie Pou | | | | | valerie@pou.com |
| 10 | Lashawn Hasty | | | | | lashawn@hasty.com |
| 11 | Marianne Earman | | | | | marianne@earman.com |
| 12 | Justina Dragaj | | | | | justina@dragaj.com |
| 13 | Mandy Mcdonnell | | | | | mandy@mcdonnell.com |
| 14 | Conrad Lanfear | | | | | conrad@lanfear.com |
| 15 | Cyril Behen | | | | | cyril@behen.com |
| 16 | Shelley Groden | | | | | shelley@groden.com |
| 17 | Rosalind Krenzke | | | | | rosalind@krenzke.com |
| 18 | Davis Brevard | | | | | davis@brevard.com |

Flash Fill: Automating String Processing in Spreadsheets using Input-Output Examples, Sumit Gulwani [POPL 2011]



| input | output |
|-------|--------|
| 1 | 3 |
| 4 | 6 |
| -1 | 1 |
| 35 | 37 |

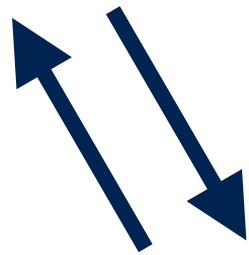


$$f(x) = x+2$$

```
def add (x)  
    return x+2  
end
```

How it works

Set of Functions



Specification



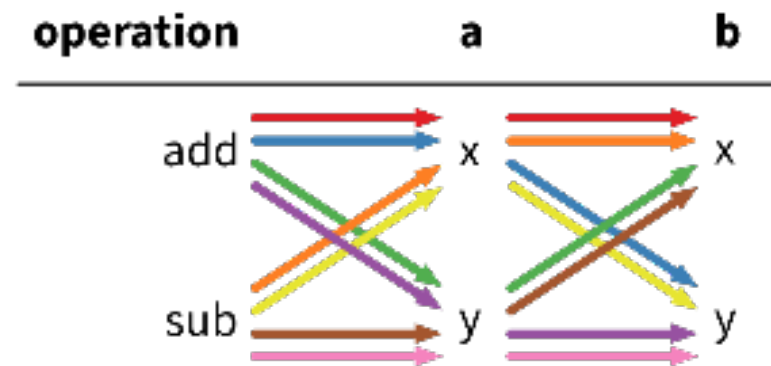
Synthesizer



Program

| input | output |
|--------|--------|
| [0, 0] | 0 |
| [1, 0] | 1 |

Set of Functions



add(x, x)
add(x, y)
add(y, x)
add(y, y)
sub(x, x)
sub(x, y)
sub(y, x)
sub(y, y)

$$\begin{aligned}2 \times (2)^2 &= 8 \\2 \times (2+8)^2 &= 200 \\2 \times (2+8+200)^2 &= 88,200 \\&\dots \\2 \times (2+8+200+\dots)^2 &= \infty\end{aligned}$$

Specification

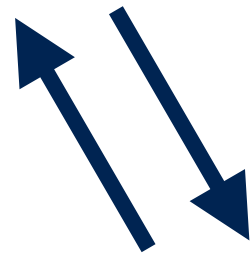


| input | output |
|--------|--------|
| [0, 0] | 0 |
| [1, 0] | 1 |

SO MANY POSSIBLE
PROGRAMS!!!

Program

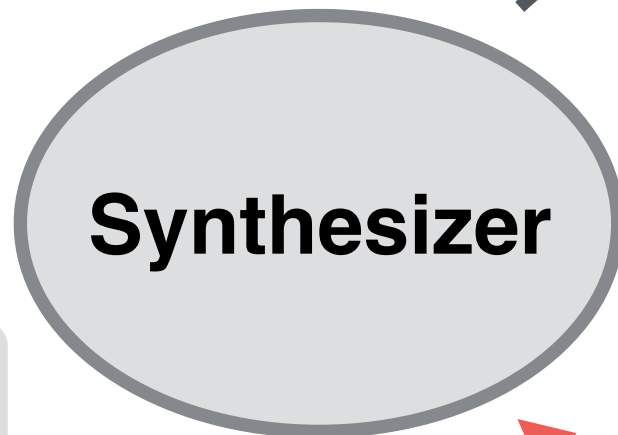
Set of Functions



Specification

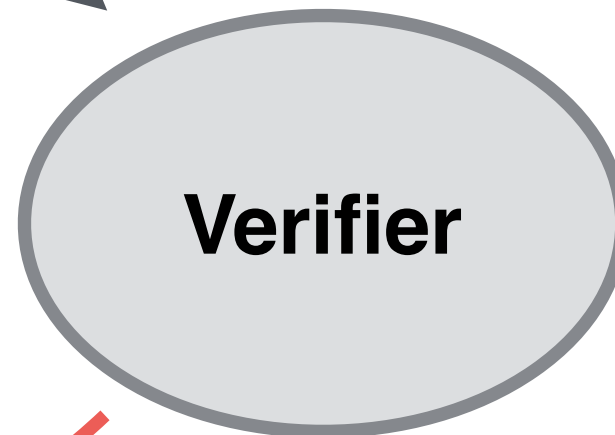


| input | output |
|--------|--------|
| [0, 0] | 0 |
| [1, 0] | 1 |



Synthesizer

**Candidate
Program**



Verifier

Success



Program

Failure

Feedback



Set of Functions

For Example...



$$P1(x,y)=\text{sqrt}(x)+y$$

$$P2(x,y)=x+y$$

$$P3(x,y)=\text{sqrt}(x+y)$$

Specification



Synthesizer

Verifier

| input | output |
|--------|--------|
| [0, 0] | 0 |
| [1, 0] | 1 |

$$P(x,y) = \text{sqrt}(x+y)$$

Set of Functions



$$P1(x,y)=\text{sqrt}(x)+y$$

$$P2(x,y)=x+y$$

$$P3(x,y)=\text{sqrt}(x+y)$$

Specification



Synthesizer

Verifier

| input | output |
|-------|--------|
|-------|--------|

| | |
|--------|---|
| [0, 0] | 0 |
|--------|---|

| | |
|--------|---|
| [1, 0] | 1 |
|--------|---|

$$P(x,y)=\text{sqrt}(x+y)$$

| | P1 | P2 | P3 |
|--------|----|----|----|
| [0, 0] | 0 | 0 | 0 |
| [1, 0] | 1 | 1 | 1 |

Set of Functions



$$P1(x,y)=\text{sqrt}(x)+y$$

$$P2(x,y)=x+y$$

$$P3(x,y)=\text{sqrt}(x+y)$$

Specification



Synthesizer

Verifier

| input | output |
|--------|--------|
| [0, 0] | 0 |
| [1, 0] | 1 |
| [4, 5] | 3 |

$$P(x,y)=\text{sqrt}(x+y)$$

| | P1 | P2 | P3 |
|-------|----|----|----|
| [0,0] | 0 | 0 | 0 |
| [1,0] | 1 | 1 | 1 |
| [4,5] | 7 | 9 | 3 |

Set of Functions



$$P1(x,y)=\text{sqrt}(x)+y$$

$$P2(x,y)=x+y$$

$$P3(x,y)=\text{sqrt}(x+y)$$

Specification



| input | output |
|-------|--------|
|-------|--------|

| | |
|--------|---|
| [0, 0] | 0 |
|--------|---|

| | |
|--------|---|
| [1, 0] | 1 |
|--------|---|

| | |
|--------|---|
| [4, 5] | 3 |
|--------|---|

$$P(x,y)=\text{sqrt}(x+y)$$

Synthesizer

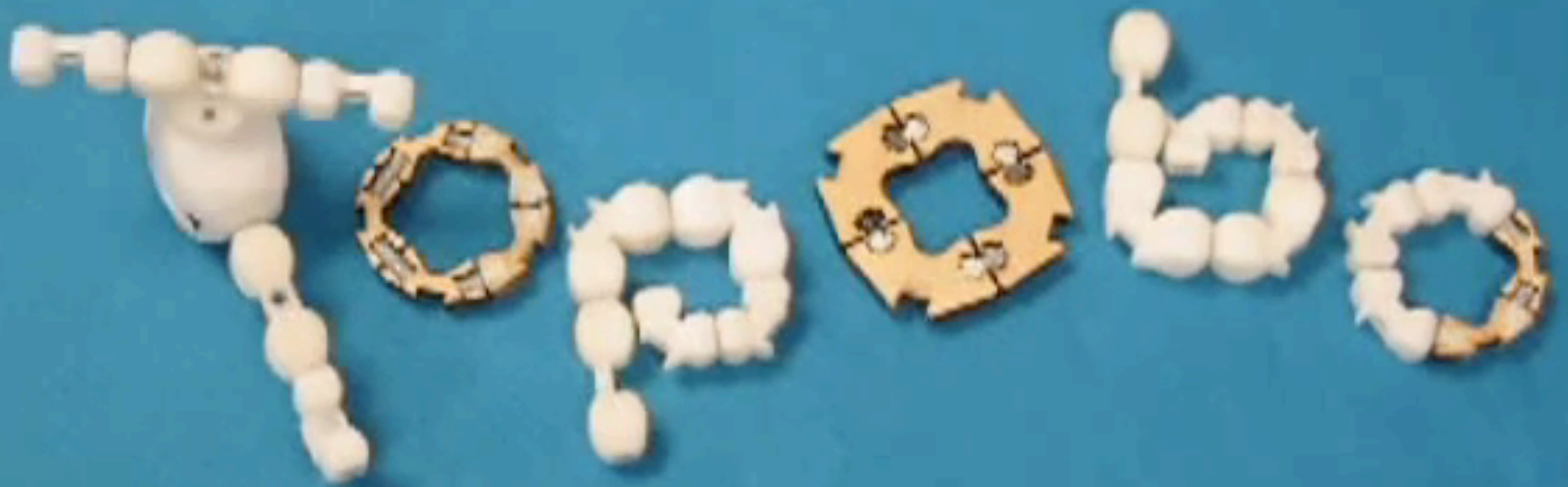
Verifier

Success

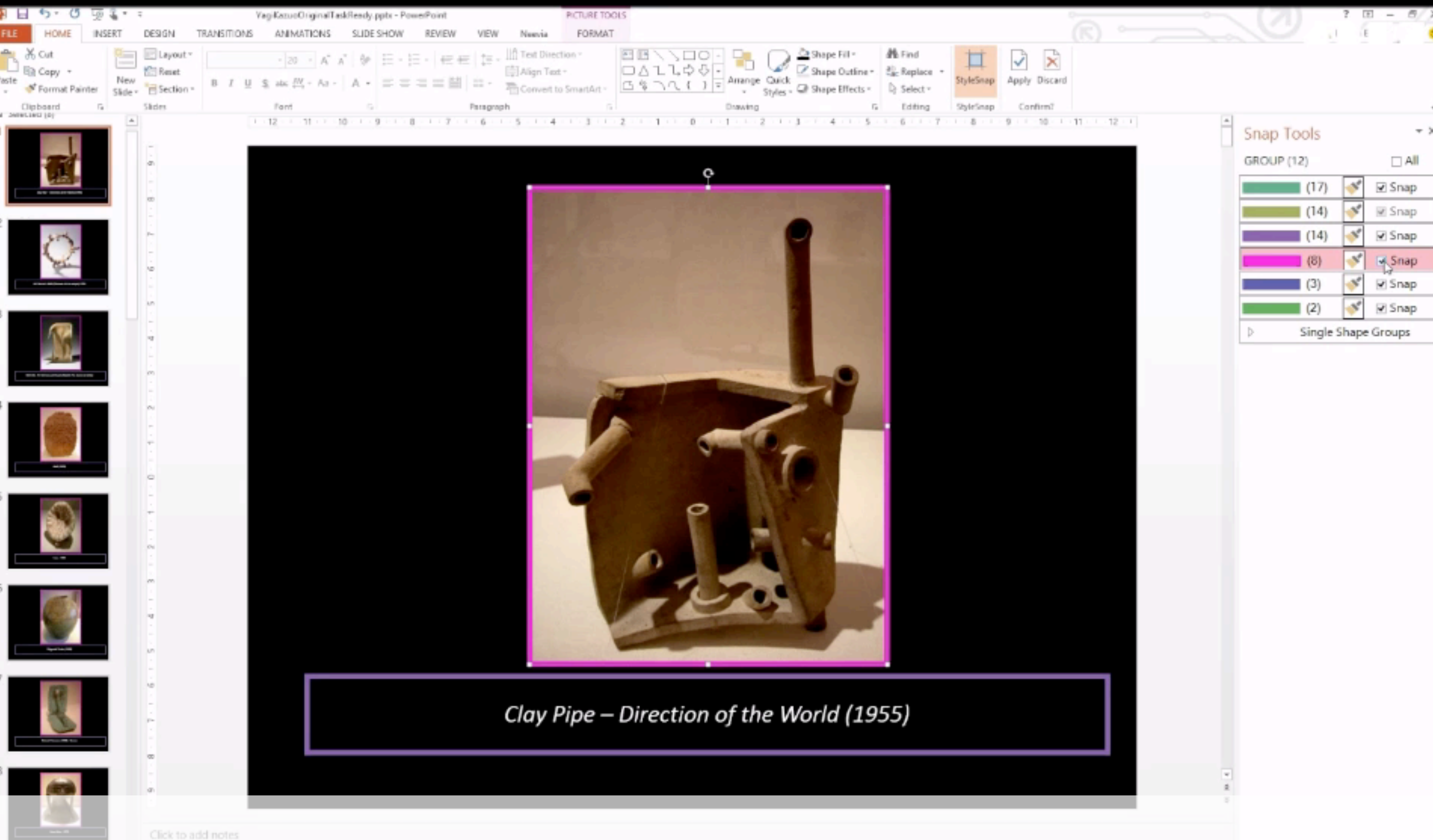
$P3(x,y)$

| | P1 | P2 | P3 |
|--------|----|----|----|
| [0, 0] | 0 | 0 | 0 |
| [1, 0] | 1 | 1 | 1 |
| [4, 5] | 7 | 9 | 3 |
| | X | X | ✓ |

Applications



Topobo: a constructive assembly system with kinetic memory
Hayes Solo Raffle et al. , [CHI 2004]

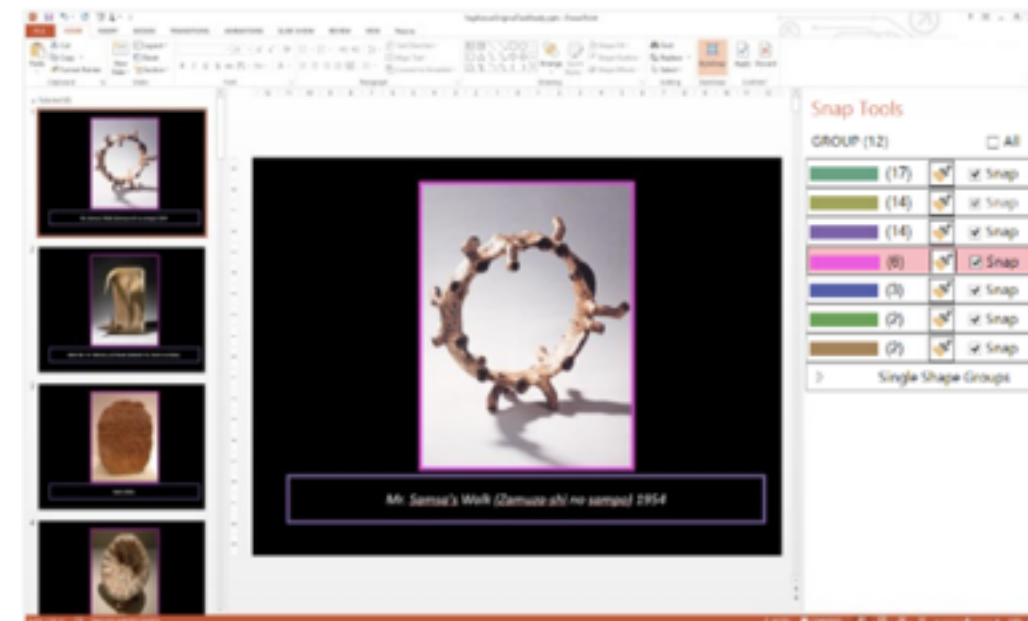


StyleSnap: Mixed-Initiative Approaches to Global Editing in Slideware
Darren Edge et al. [CHI 2015]

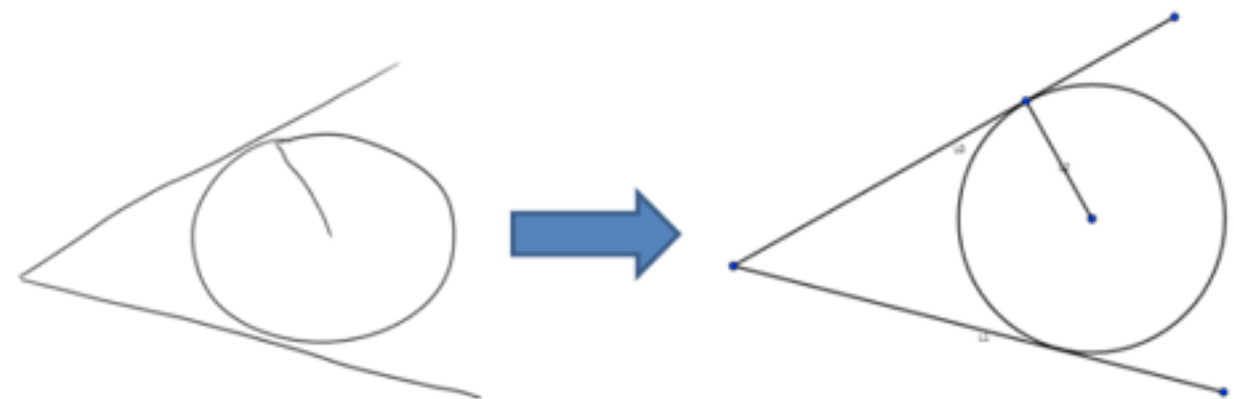
Now you can see the Snap effect on the whole group.

Productivity Tools

Robotics



Drawings





In this project, we propose

Data Extraction on the Web

I have a
headache
DEMO

Conclusion

- 1. Survey Programming by Example and its applications**
- 2. Prototype a data extraction and visualization tool for end-user**

Thank you

Ryo Suzuki

PhD in Human-Computer Interaction Group