Learning from raw data with low-level symbols alone

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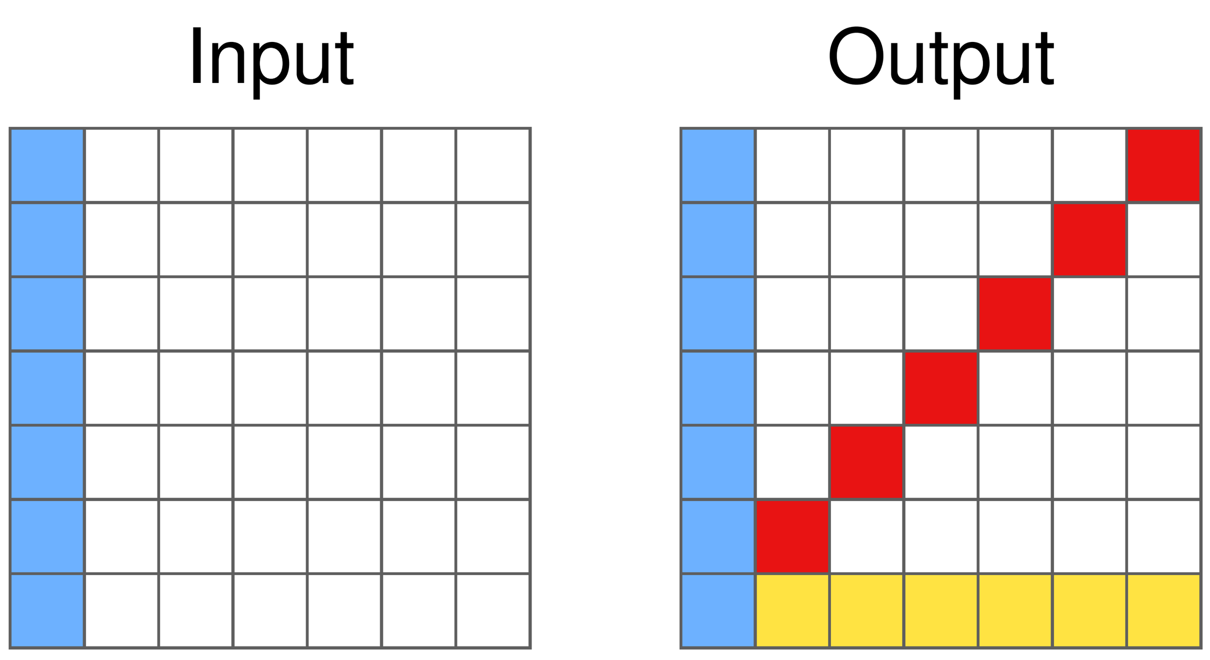
Contribution

We show symbolic approaches can learn directly from raw data, such as individual pixels, by learning relations between raw elements.

Visual reasoning




```
out(X,Y,C) :- in(X,Y,C).
out(X,Y,yellow) :- empty(X,Y), height(X).
out(X,Y,red) :- empty(X,Y), height(X+Y-1).
```

- An output pixel is colour C if it is colour C in the input.
- An output pixel is yellow if it is in the bottom row and empty in the input.
- An output pixel is red if it is empty in the input and the sum of its coordinates X and Y equals $H+1$, i.e. it is on the diagonal.

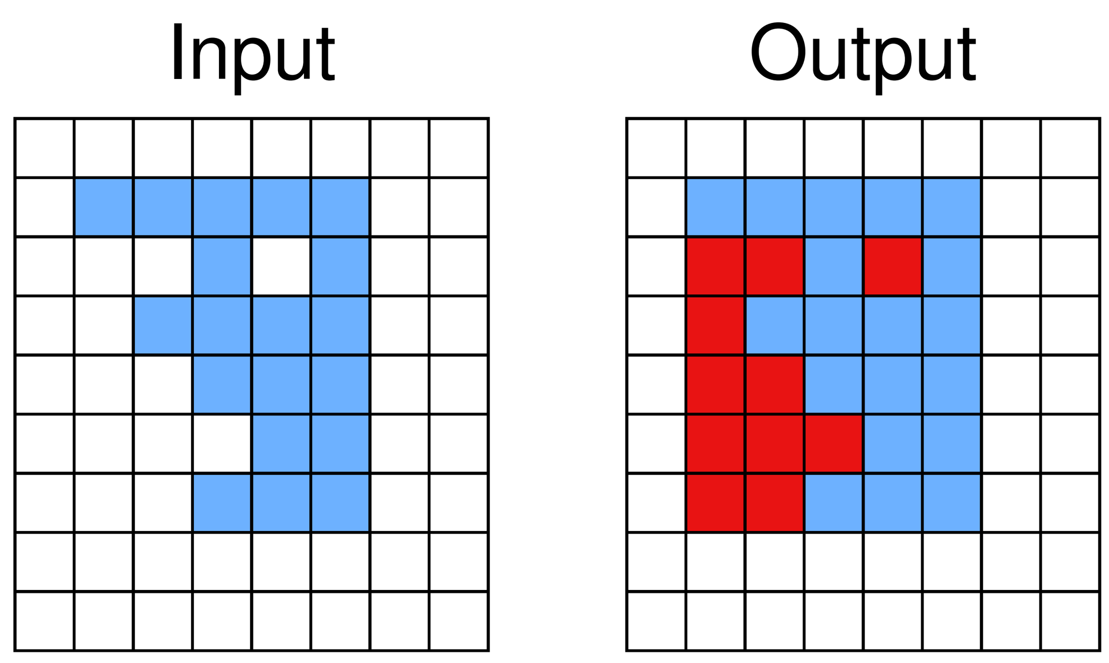
List functions

Input	**Output**
[81, 43]	[2, 43, 81, 2]
[1, 63, 21, 16]	[4, 16, 21, 63, 1, 4]

```
out(1,E-1):- end(E).
out(I,V):- end(E), in(I1,V), add(I,I1,E+1).
out(E+1,E-1):- end(E).
```

- The output element at index 1 is $E-1$, i.e. the size of the input list.
- The output element at index I is the input element at index $I1$, where $I+I1=E+1$.
- The output element at index $E+1$ is $E-1$.

Visual reasoning

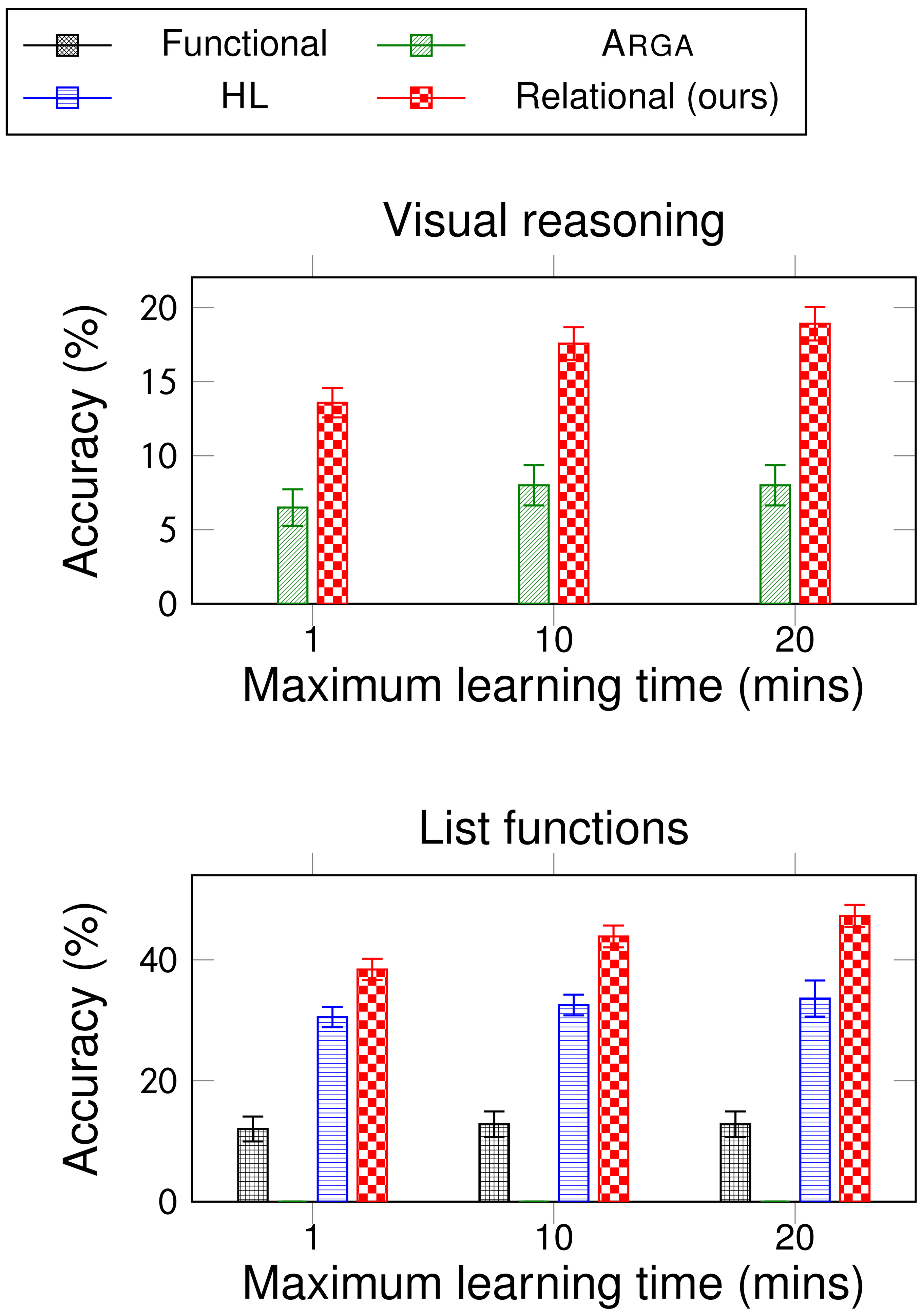



```
out(X,Y,C):- in(X,Y,C).
out(X,Y,red):- empty(X,Y), in(X1,Y,C), in(X,Y1,C).
```

- An output pixel is colour C if it is colour C in the input.
- An output pixel is red if it is empty in the input and
  - an input pixel in the row X has colour C, and
  - an input pixel in the column Y has colour C.

Evaluation

How does a general-purpose symbolic system with a relational representation compare against domain-specific approaches?



Reference

Céline Hocquette and Andrew Cropper, *Relational decomposition for program synthesis*, 2024.