Introduction to Programming CS101

Fall 2011

Lecture #12

Advertisement: CS109

Did you like CS101 so far? Would you like to learn more about programming?

Starting next spring, the CS department is offering CS109 "Programming Practice". It is especially meant for students who did NOT learn programming in high school and who want to learn and practice more programming than we can teach in CS101.

If you consider majoring computer science but did not learn programming in high school, then CS109 is highly recommended, as the second year computer science courses assume you are familiar with the material taught in CS109.

Please visit the CS109 homepage, if you're interested:

`http://tclab.kaist.ac.kr/~otfried/cs109/`

Course Evaluation

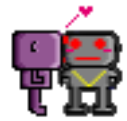
Course Evaluation

- When: December 1, 10AM – December 14, 5PM
- Where: KAIPA (`http://kaipa.kaist.ac.kr`)

Roadmap

In the first half of the semester we covered

- Why we learn programming
- Boolean values / conditionals / loops
- Objects / types / variables / methods / operators / expressions / tuples
- Functions / Function parameters / Lists
- Local and global variables / modules / graphics
- String methods / Image manipulation



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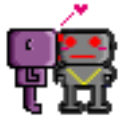
In the second half of the semester we are covering

- Object creation
- File I/O
- How to control a system
- Object consructors / User interface programming
- Interpreters vs compilers / Recursion



Speed

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Machine language is just numbers in the memory:

```
21 37 158 228 255 10 49 26 88 250 12 ...
```

Each number means some instruction:

- Load value from memory to CPU register
- Add two register values
- Store register value to memory
- Compare two numbers
- Jump to a new memory address

Interpreters & Compilers

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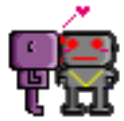
Languages such as C, C++, Java, or FORTRAN are compiled. The input program (source code) is converted to a numeric format that contains machine instructions.



Interpreters & Compilers

Using an interpreter is like making a dish using a cooking book in a foreign language that you cannot read well. You need to look up many words, and you execute the recipe slowly.

Fondant au chocolat

par Crevette

Pour 6 personnes :
Préparation : 20 min
Cuisson : 30 min

Ingrédients :

- 200 g de chocolat pâtissier
- 60 g de beurre
- 4 cuillerées à soupe de farine
- 4 œufs
- 150 g de sucre

Préparation :

Faire fondre le chocolat au bain-marie. Séparer les jaunes d'œufs des blancs.
Ajouter le beurre ramolli au chocolat fondu, ensuite les jaunes d'œufs, le sucre et la farine.

Montez les blancs d'œufs en neige bien ferme. Incorporez-les délicatement au mélange.
Cuire au four à 180°C (th.6) pendant environ 30 minutes.

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It takes time and effort to do the translation and to write it down. It is not worth doing that if we only cook the dish once. But now we can cook the dish many times quickly.

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Memory-management is done automatically by the interpreter.

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A smart algorithm in an interpreted language can easily beat a simple algorithm in a compiled language.

Example: Sorting

Here is a simple algorithm to sort a list a:

```
for i in range(len(a) - 1):
  for j in range(len(a) - 1):
    if a[j] > a[j+1]:
      a[j], a[j+1] = a[j+1], a[j]
```

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If the list `a` has n elements, then the `if` statement is executed $(n-1)^2$ times.

On a 2.8 GHz desktop, sorting 10000 numbers takes 20 seconds.

Merge Sort: a smarter algorithm

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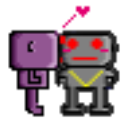

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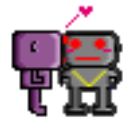

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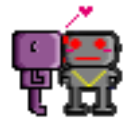

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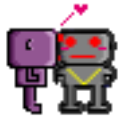
Sorting 10000 numbers on the same desktop computer takes 0.1 seconds. One million numbers can be sorted in 11 seconds.



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We can prove that it is impossible to sort n numbers with less than $n \log_2 n$ comparisons, and therefore Merge Sort is optimal.

Recursion

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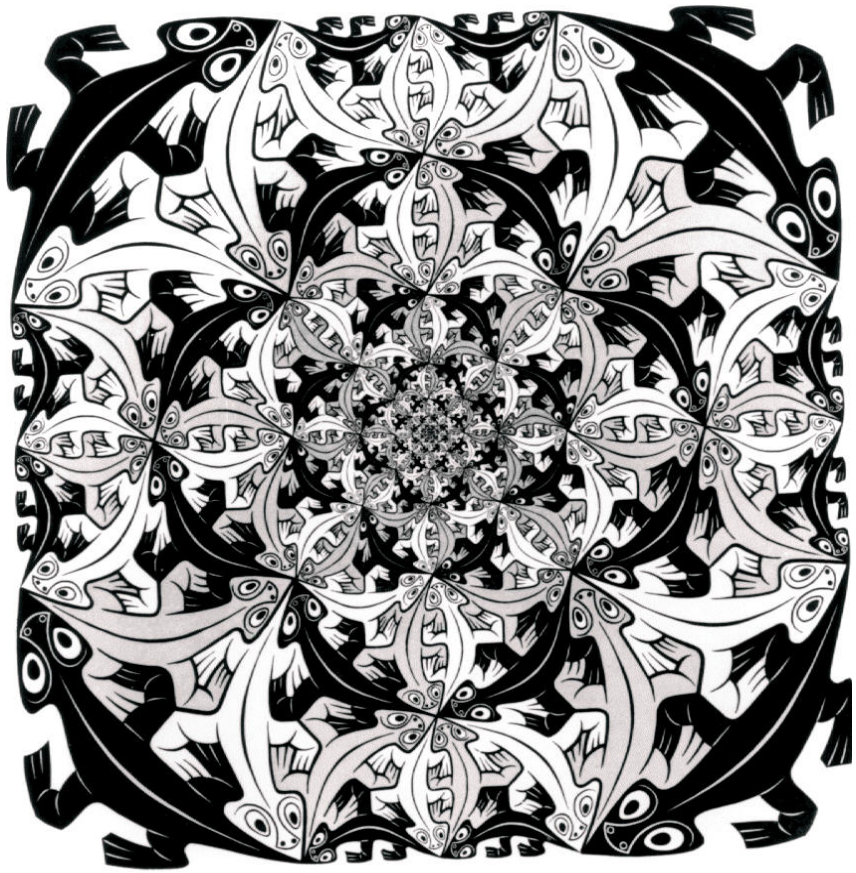

A recursive function

Factorial

$$n! = \begin{cases} 1 & \text{if } n = 0 \\ (n-1)! \times n & \text{if } n > 0 \end{cases}$$

A recursive function

How would you implement this function?

```
>>> downup("Hello")
Hello
Hell
Hel
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My solution:

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def downup(w):
    print w
    if len(w) <= 1:
        return
    downup(w[:-1])
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recursive call

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The last digit of number `n` in base `b` is easy: `n % b`

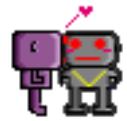
The remaining digits are the representation of `n / b` in base `b`:

```
def to_radix(n, b):
  if n < b:
    return str(n)
  s = to_radix(n / b, b)
  return s + str(n % b)
```

Merge Sort is recursive

Merge Sort is an example of a more interesting recursive algorithm: it uses two recursive calls:

```
def merge_sort(a):
  if len(a) <= 1:
    return
  m = len(a)/2
  a1 = a[:m]
  a2 = a[m:]
  merge_sort(a1)
  merge_sort(a2)
  merge(a, a1, a2)
```



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Divide & Conquer: Divide a problem into two smaller problems. Solve the smaller problems, and combine the solutions.

Efficient algorithms for everything?

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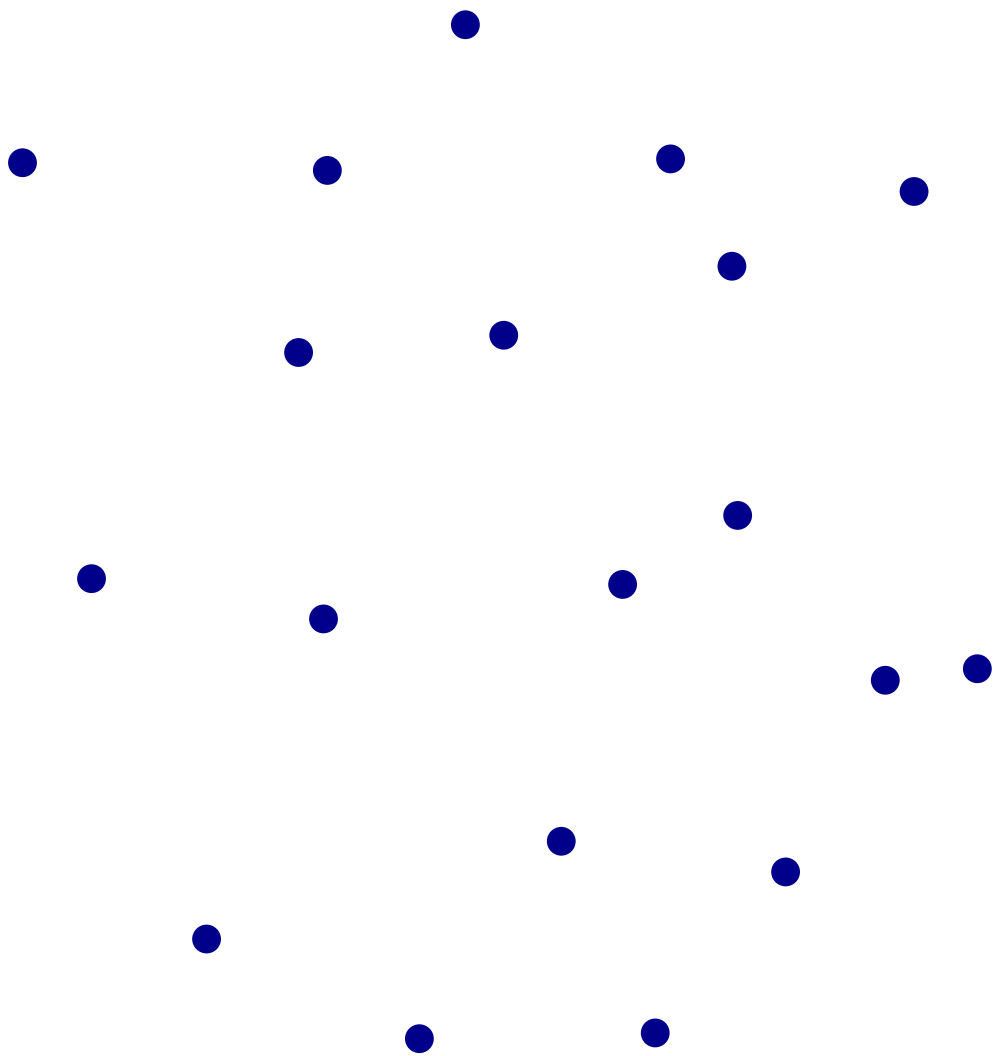

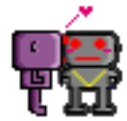

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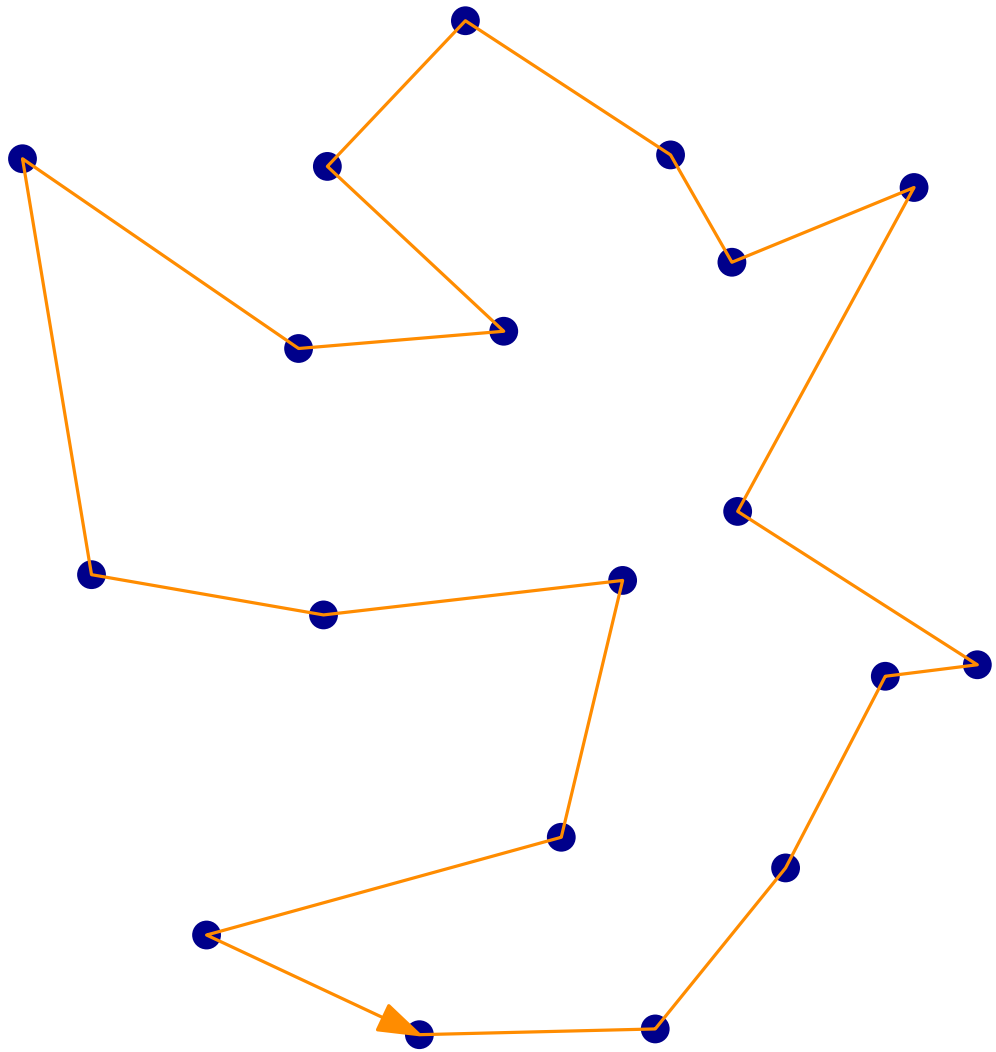

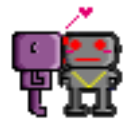

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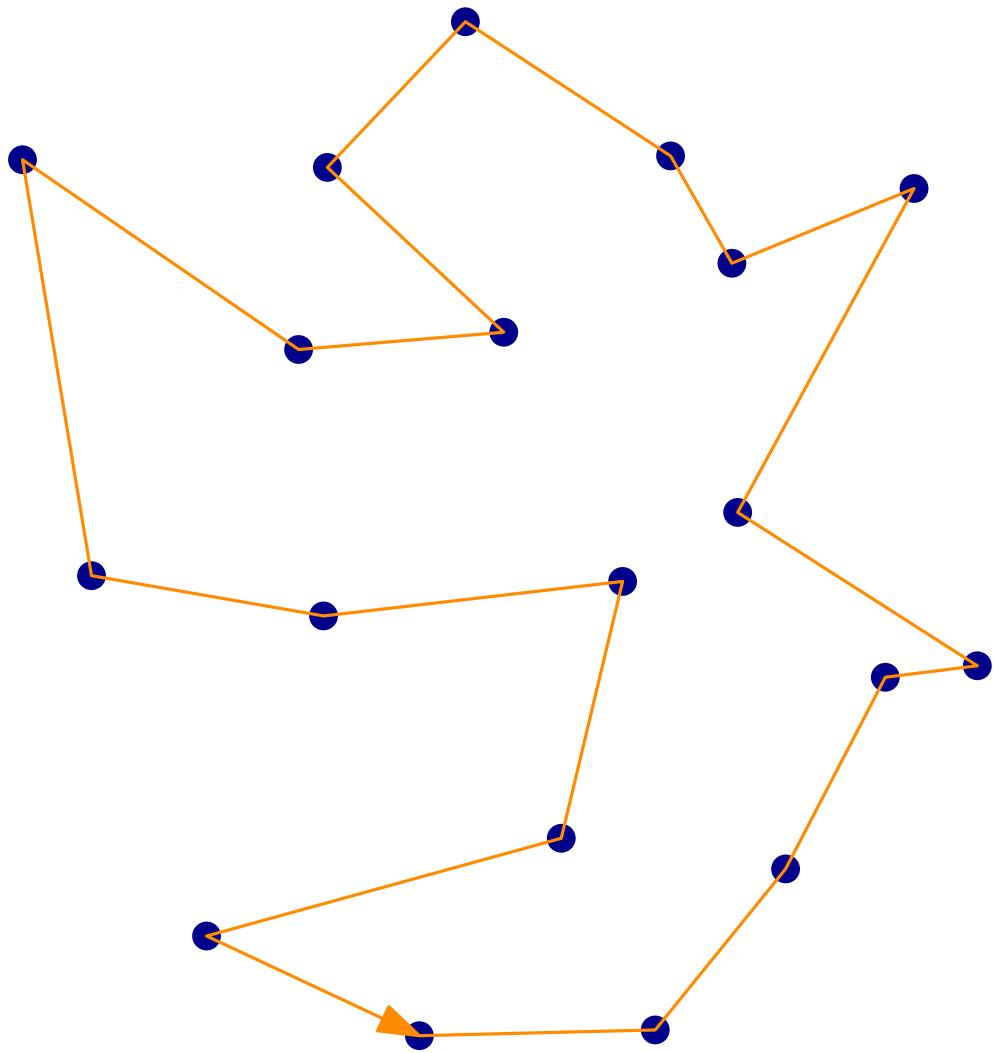

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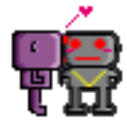

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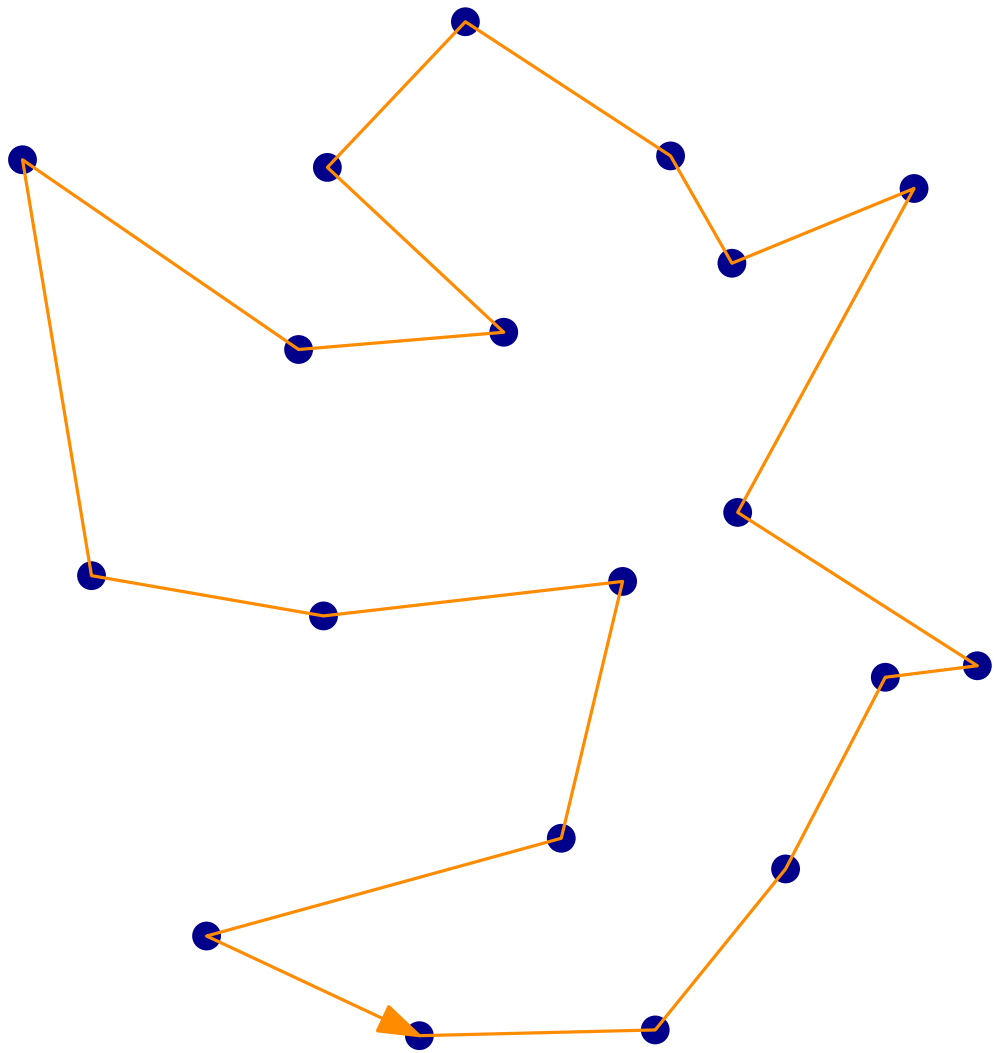

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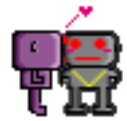

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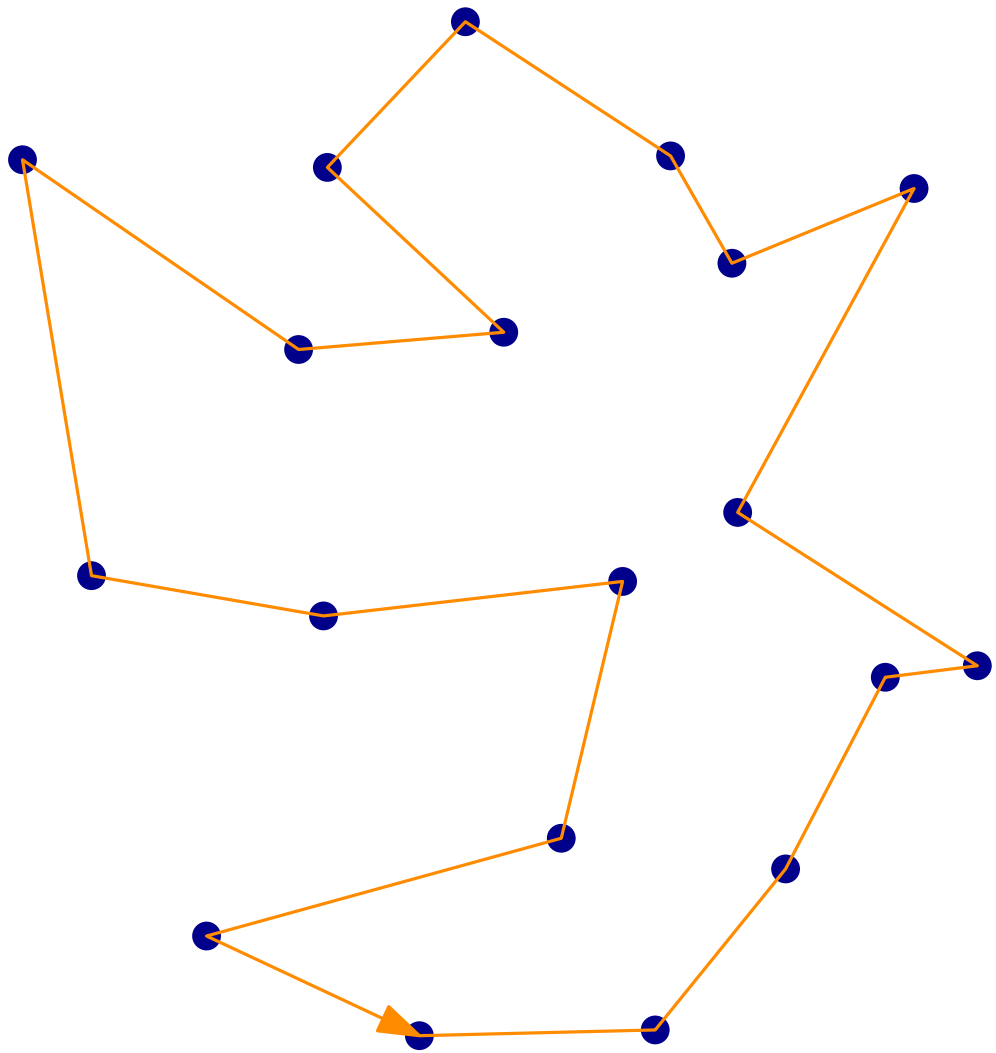

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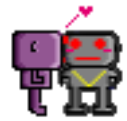

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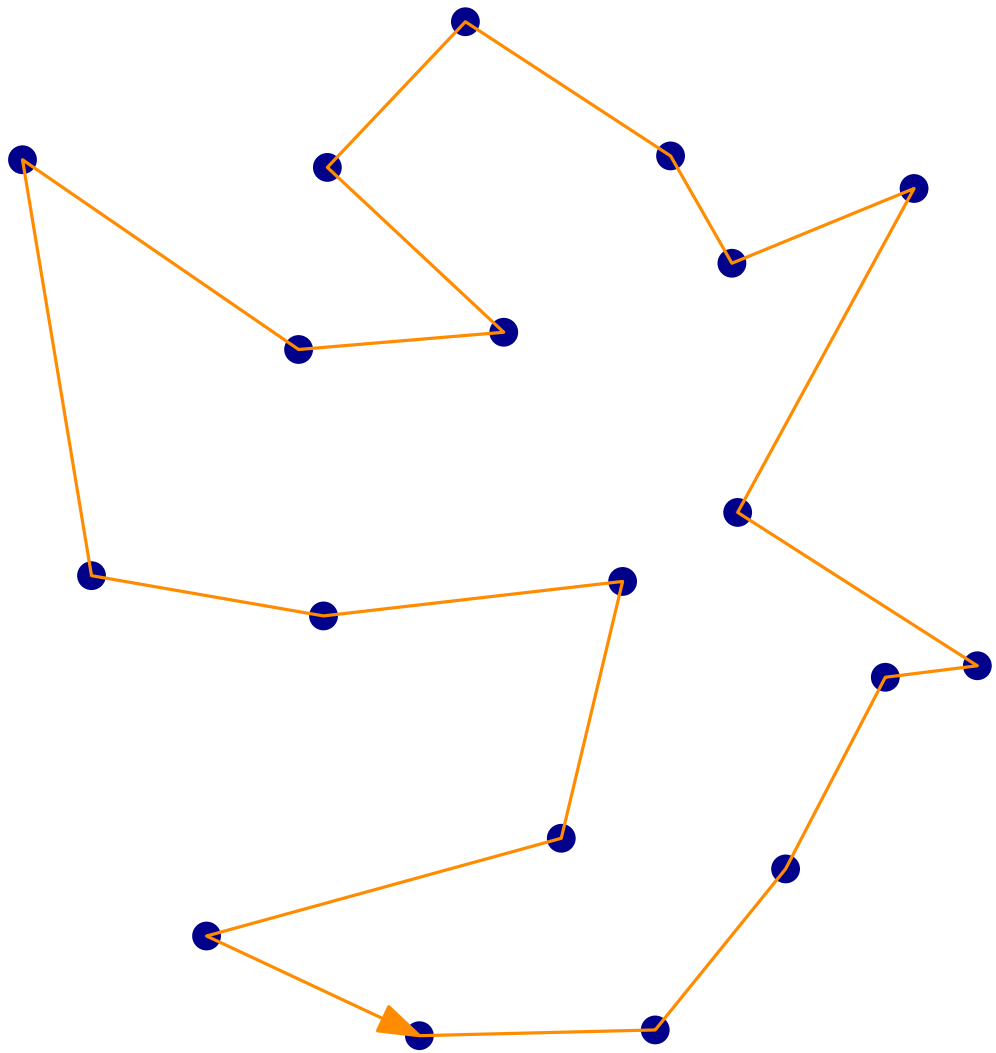

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There are problems for which we can prove that no algorithm exists.

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