

## Recognising Geometric Patterns - Example 8

Peter Fletcher, 9th September 2009.

### The problem

Figure 1 shows an image containing a single cross. A *cross* consists of a central square with four long ‘trunks’ radiating out from it, each trunk having one or more small ‘twigs’. Each trunk has the same number of twigs.

The task of the program is to recognise the pattern. The main interest of this example is in the constraint that each trunk has the same number of twigs. (An analogous string example would be  $\{a^nbc^n \mid n \geq 1\}$ , which would require a context-free grammar rather than a regular grammar.) This constraint is enforced using *subsymbols*.

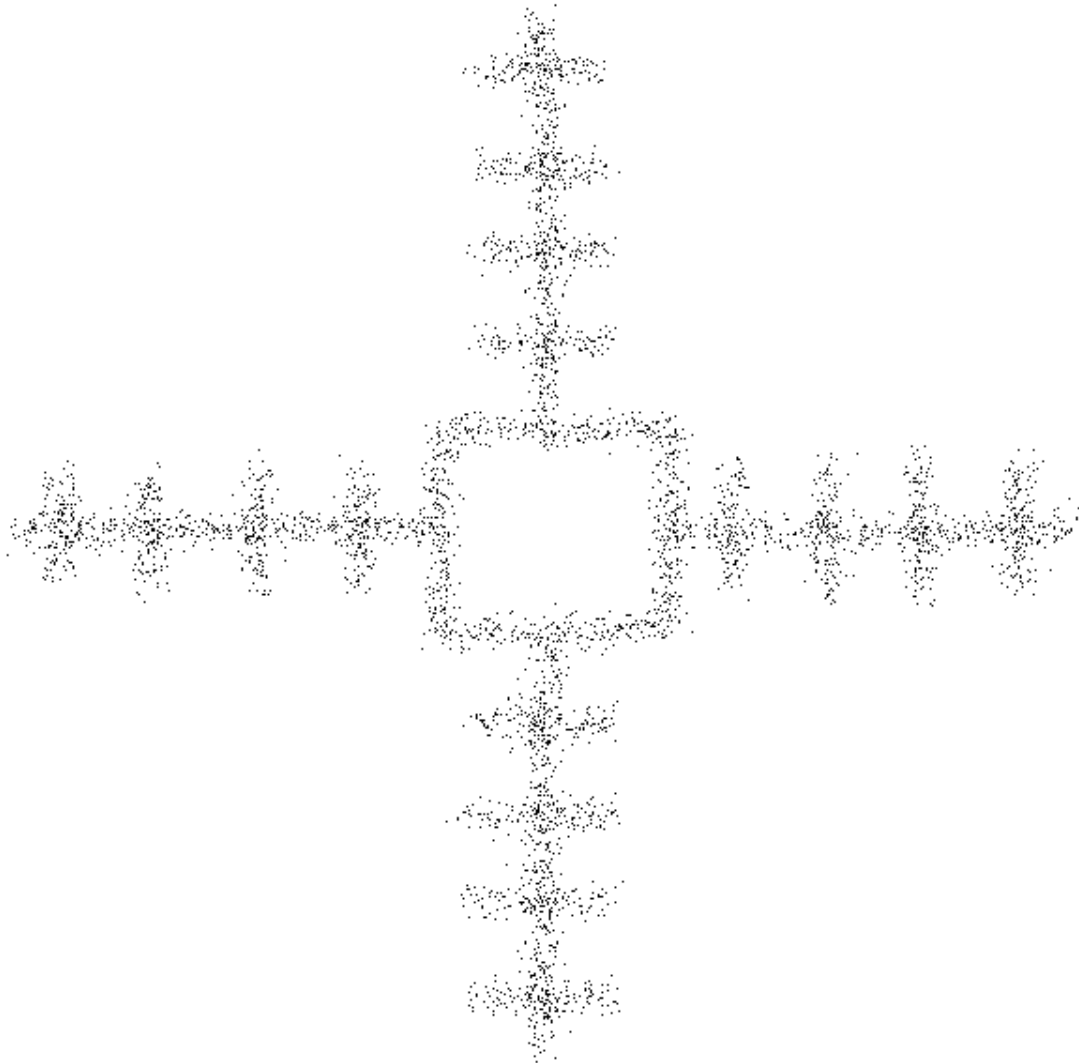


Figure 1: the original image.

The following pages show the results of the program.

## The results of the program

The program successfully finds the cross, as shown in figure 2.

The long narrow red and blue rectangles show the lines identified by the program. The large orange rectangle shows the bounding box of the cross. The black arrows mark the lines that are identified as parts of the cross (in this case, all the lines). The black discs indicate the connections between the parts (as specified by the grammar).

The four green rectangles mark the bounding boxes of *subsymbols*. (A subsymbol is a symbol whose parts are also parts of a larger symbol.) In this case the subsymbols are configurations of four twigs. Figures 3-6 show the pattern with each of the subsymbols highlighted, one at a time. Each twig must belong to one subsymbol. Consequently the subsymbols establish a one-to-one correspondence between the twigs on one trunk and the twigs on every other trunk. Hence a parse exists if and only if the trunks have the same number of twigs.

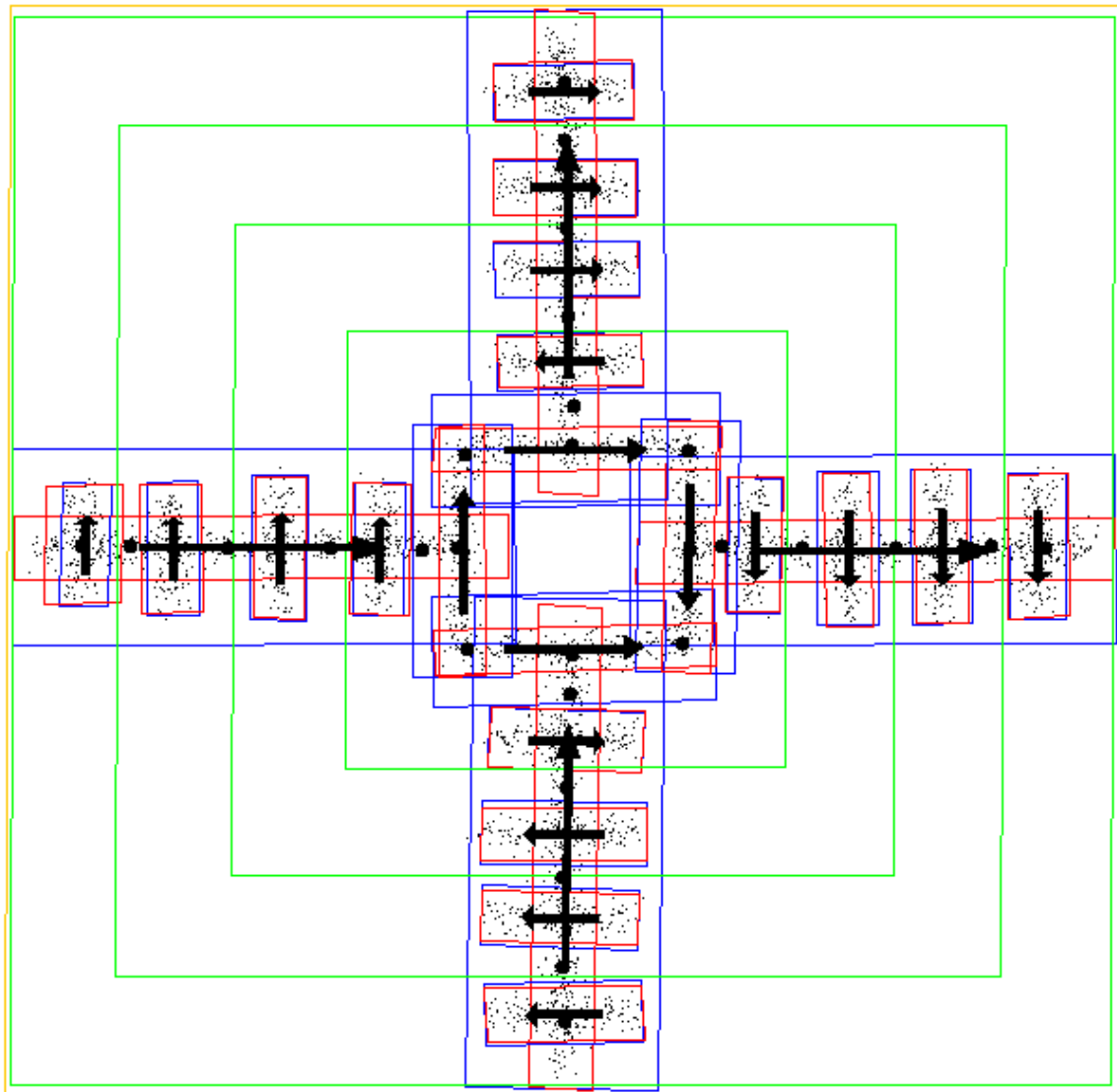


Figure 2: the cross found by the program.

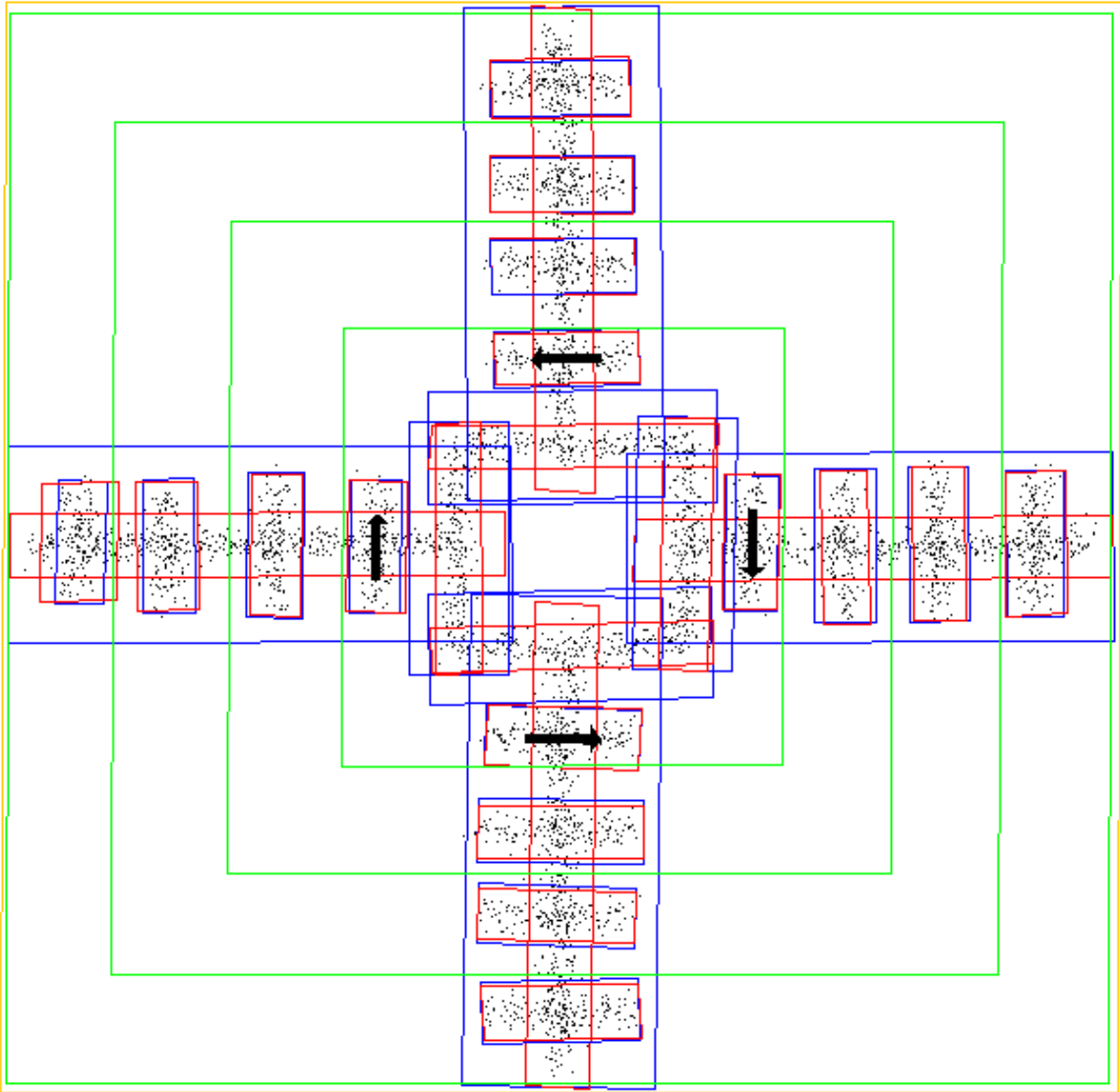


Figure 3: the cross with one subsymbol highlighted.

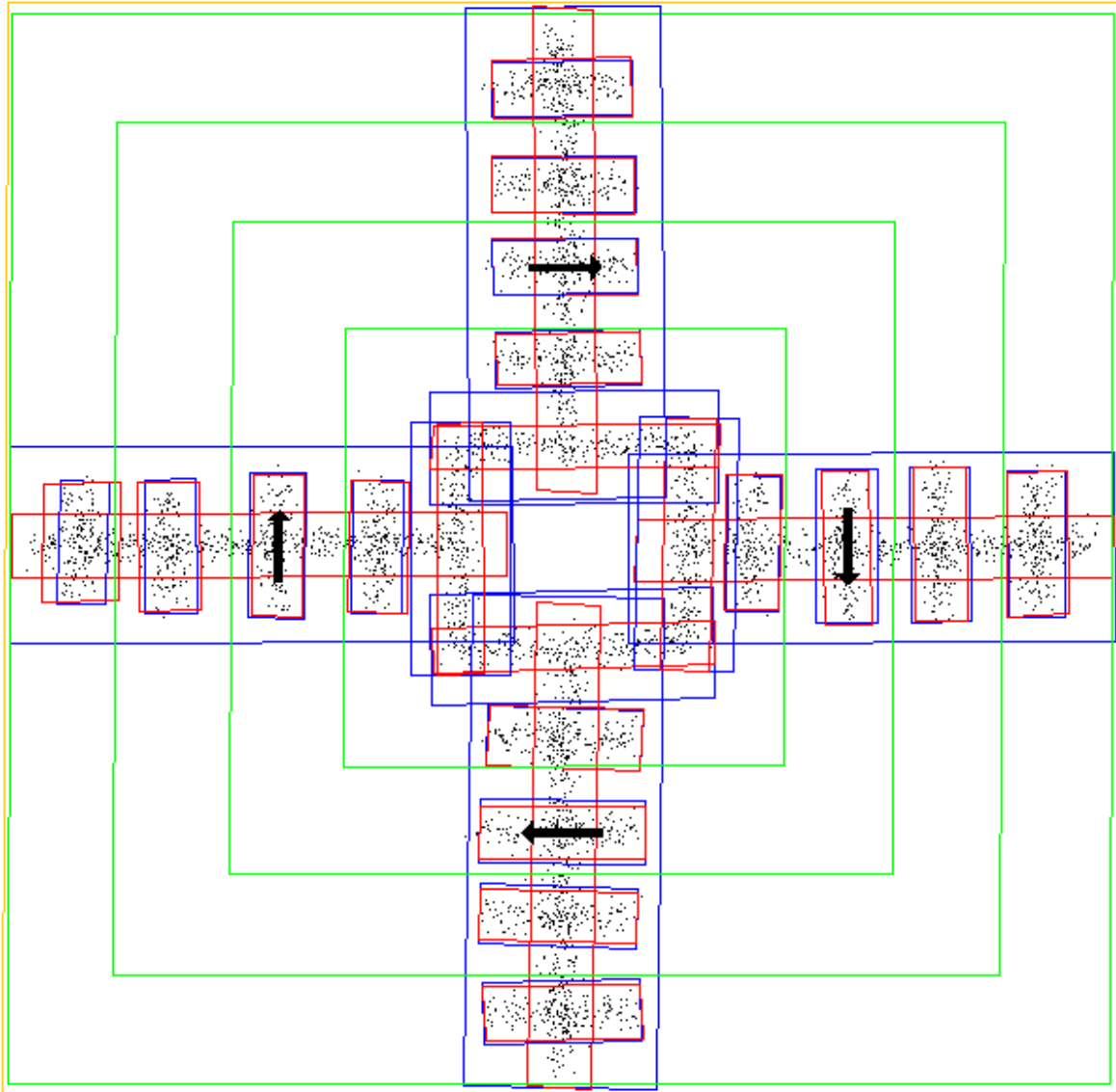


Figure 4: the cross with another subsymbol highlighted.

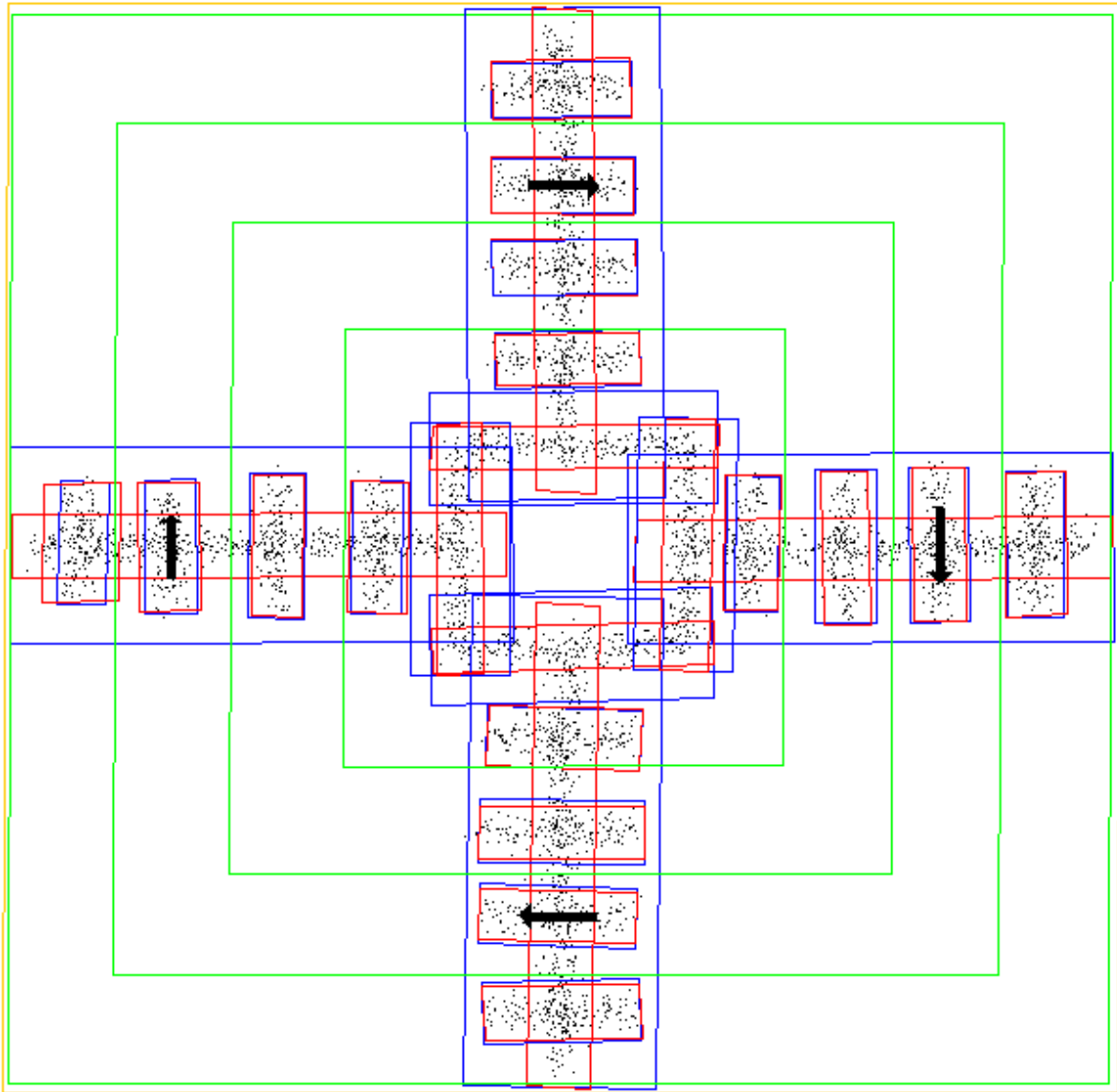


Figure 5: the cross with another subsymbol highlighted.

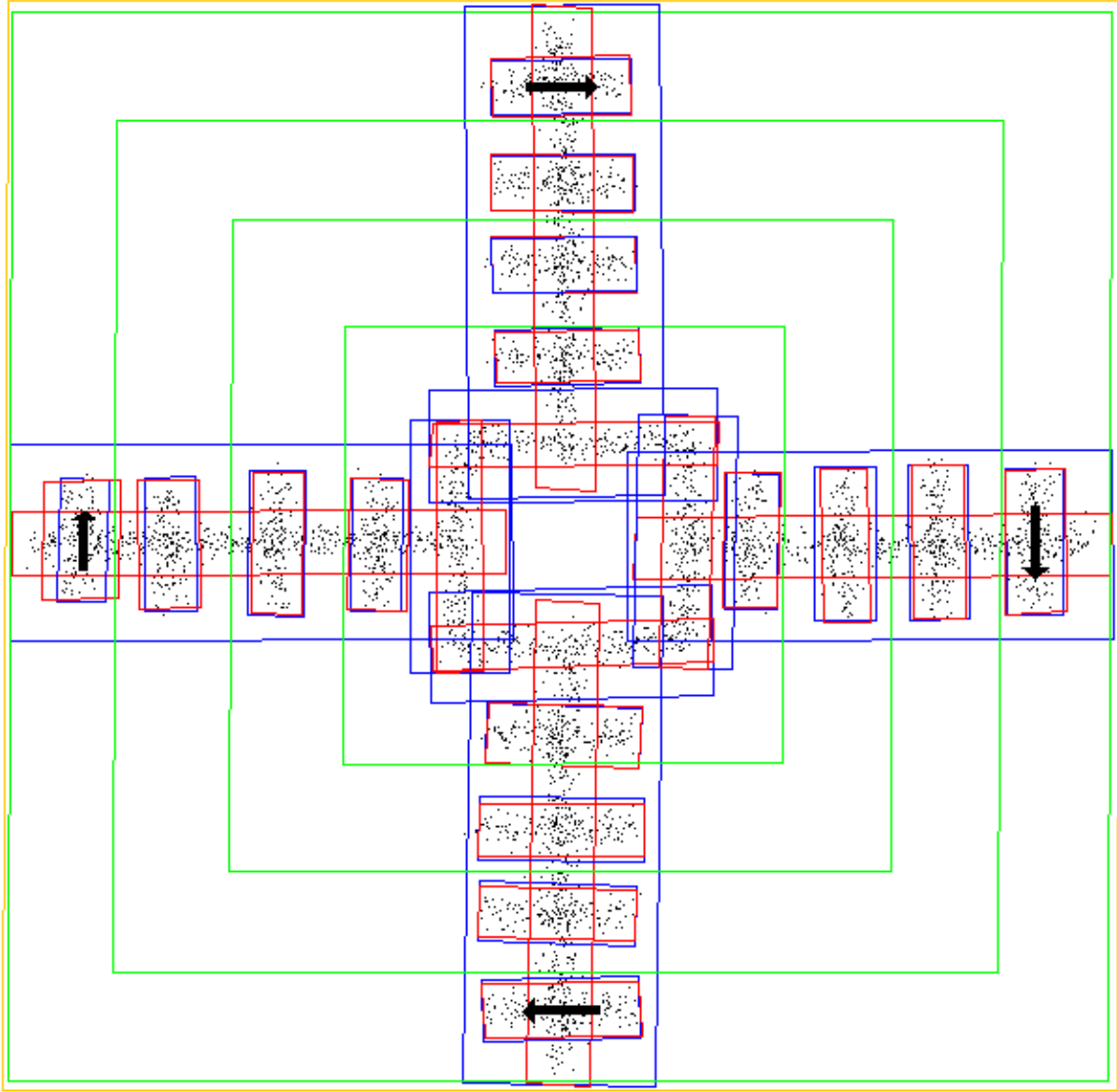


Figure 6: the cross with another subsymbol highlighted.