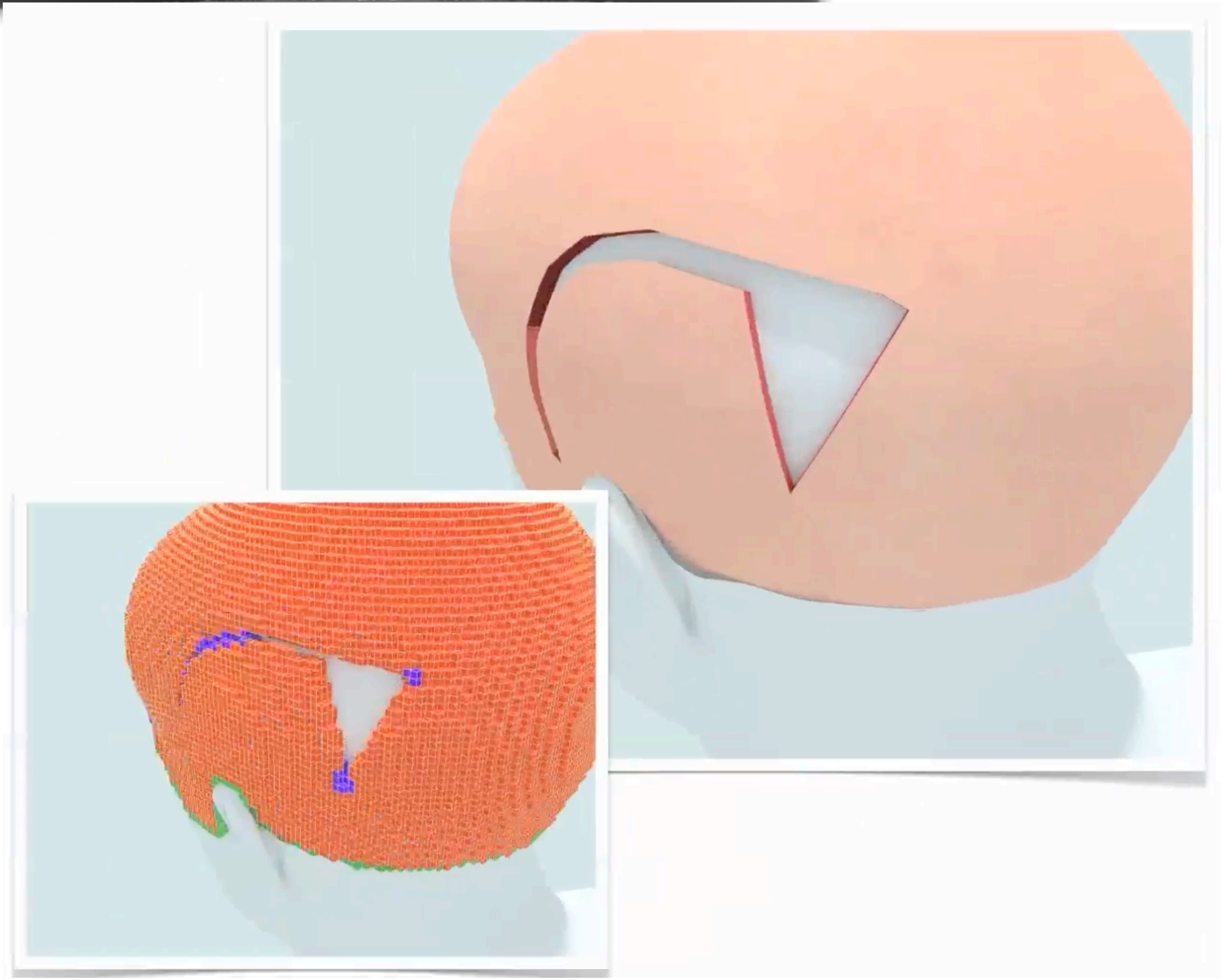
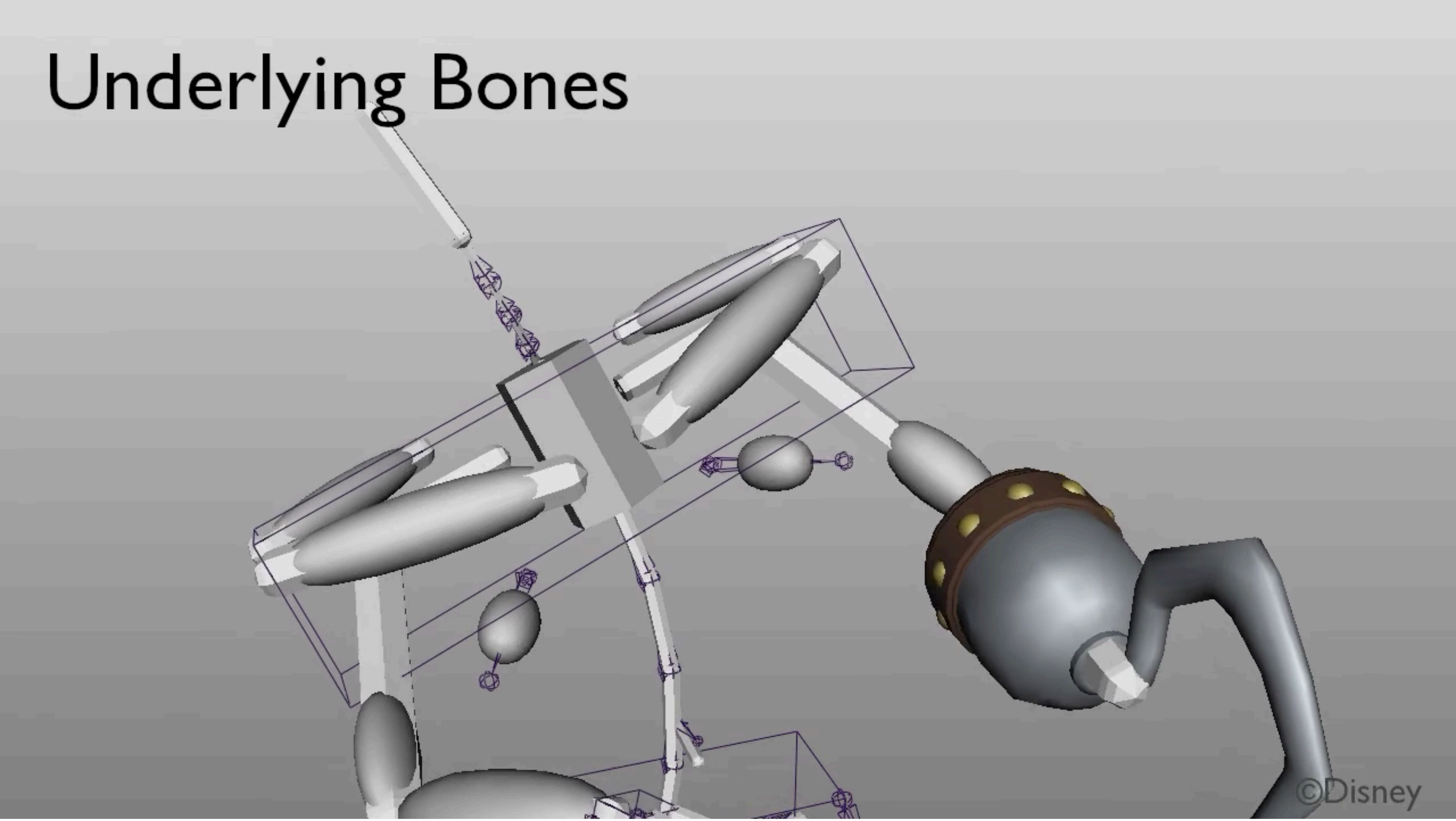
Collision detection (for simulated objects)

- Cannot (easily and efficiently) convert into levelsets to facilitate O(1) collision queries
    - Sometimes we seek collisions between open surfaces, which do not have an "*interior*" to describe as a levelset
- If simulation contains N primitives (particles, segments, triangles, etc) there is a potential for O(N^2) "*candidate*" intersection pairs
    - Brute force check would require O(N^2) cost
    - Every simulation step ideally requires O(N) effort
      (e.g. with Forward Euler, or BE with fixed CG iterations)
    - Ideally the detection cost should not exceed O(N) by much
- Popular approach : Using axis-aligned bounding box (AABB) queries to accelerate collision detection

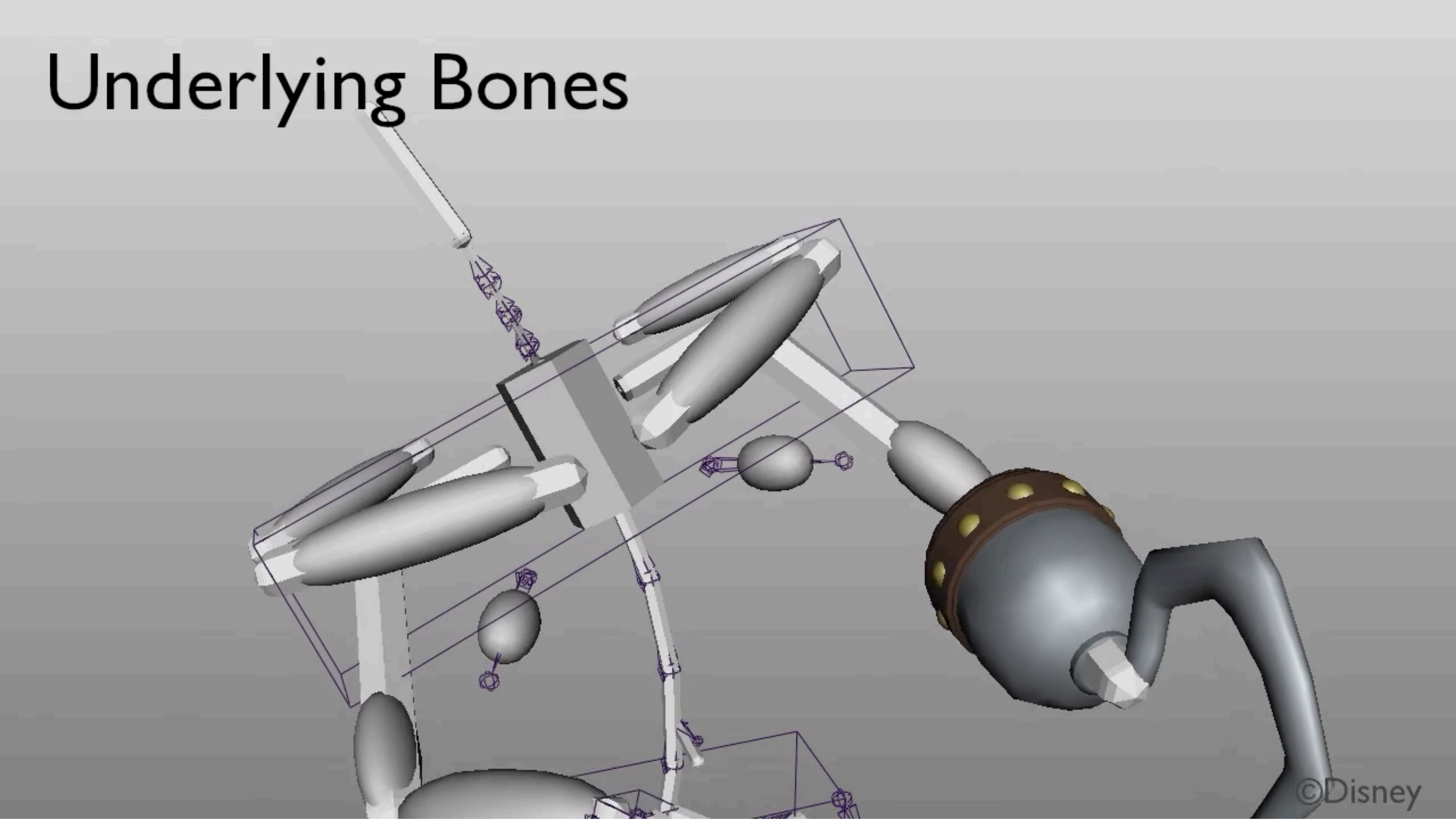
Embedded collisions (w/penalty forces)



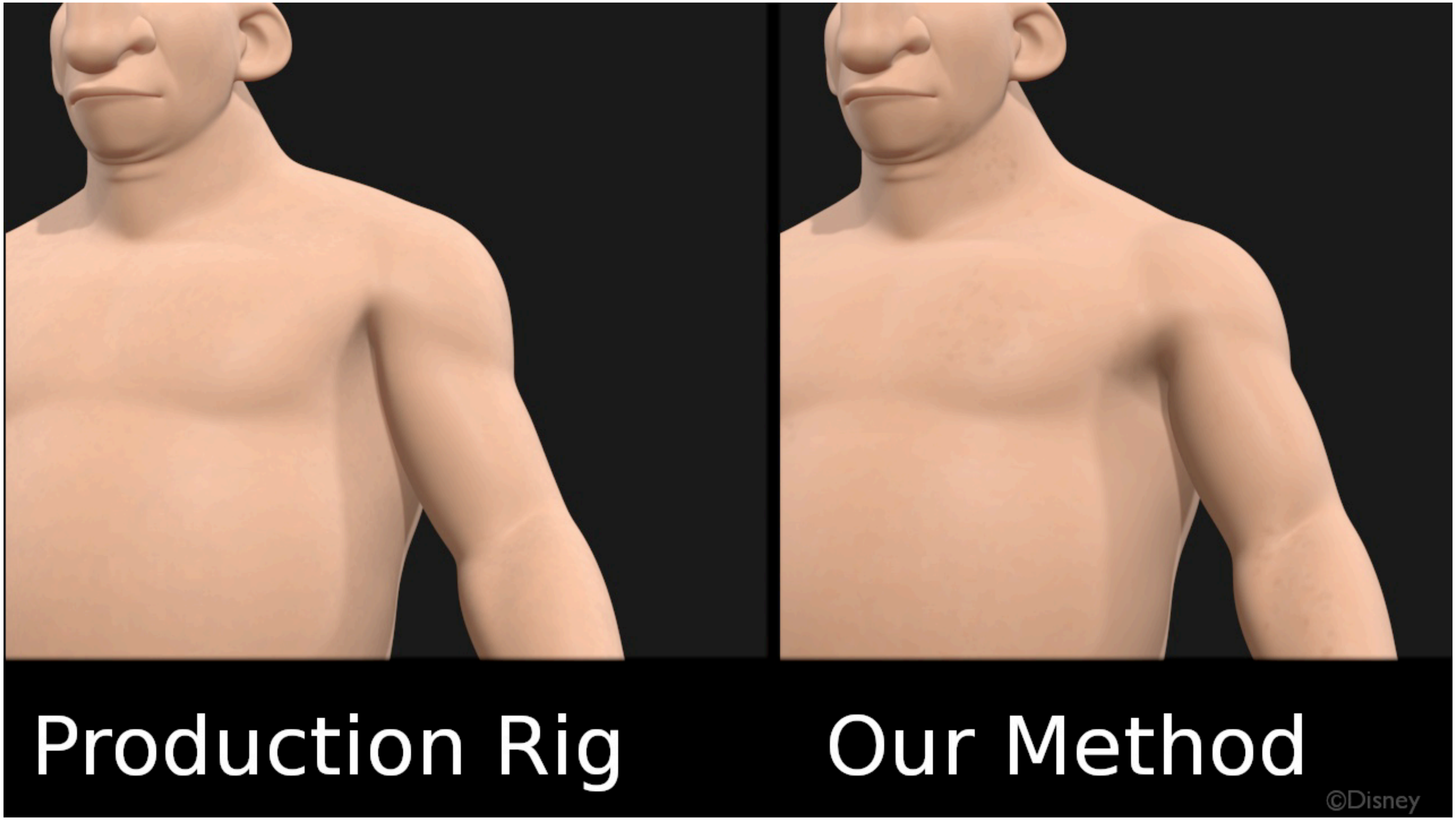
Embedded collisions (w/penalty forces)



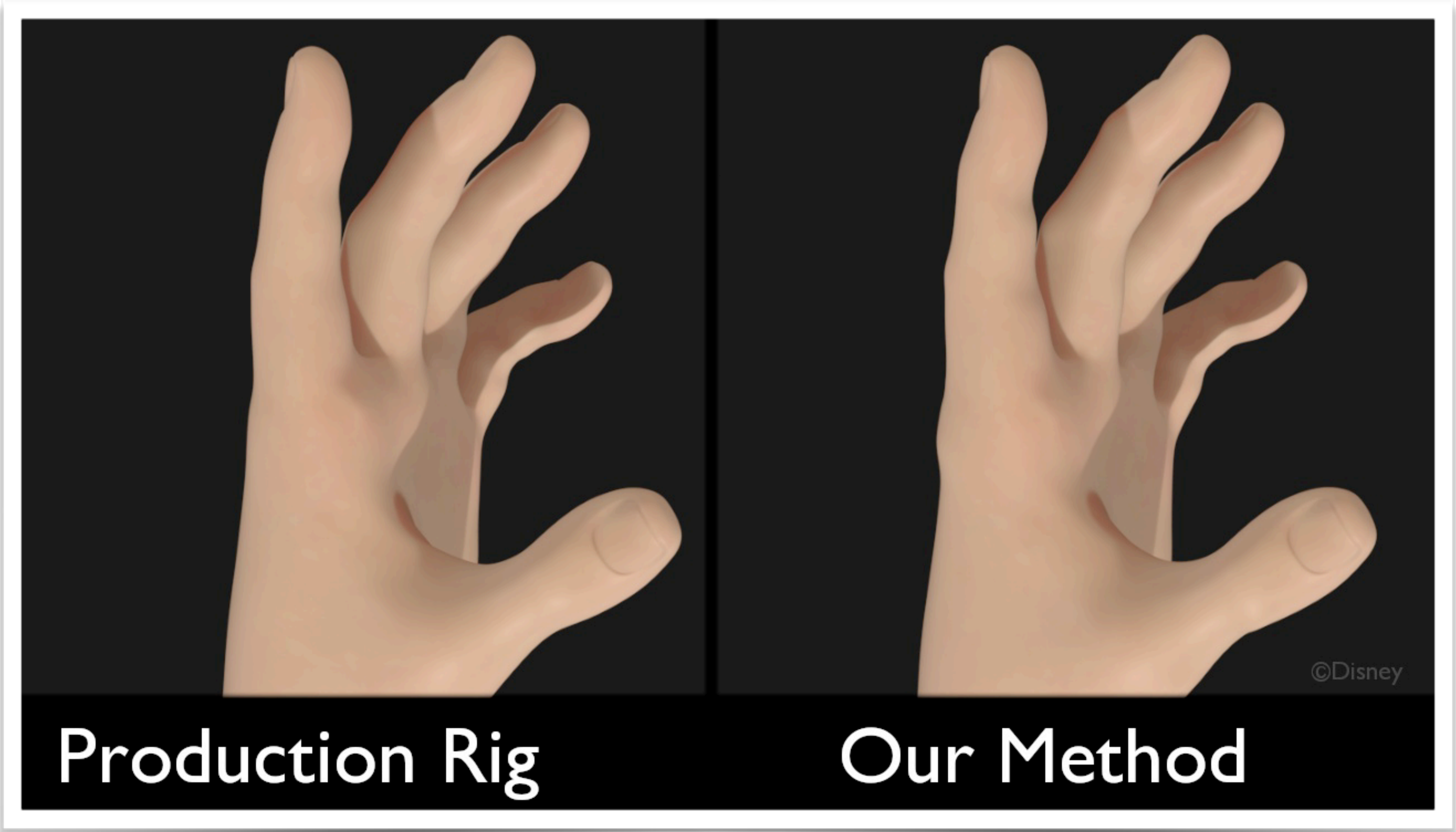
Embedded collisions (w/penalty forces)

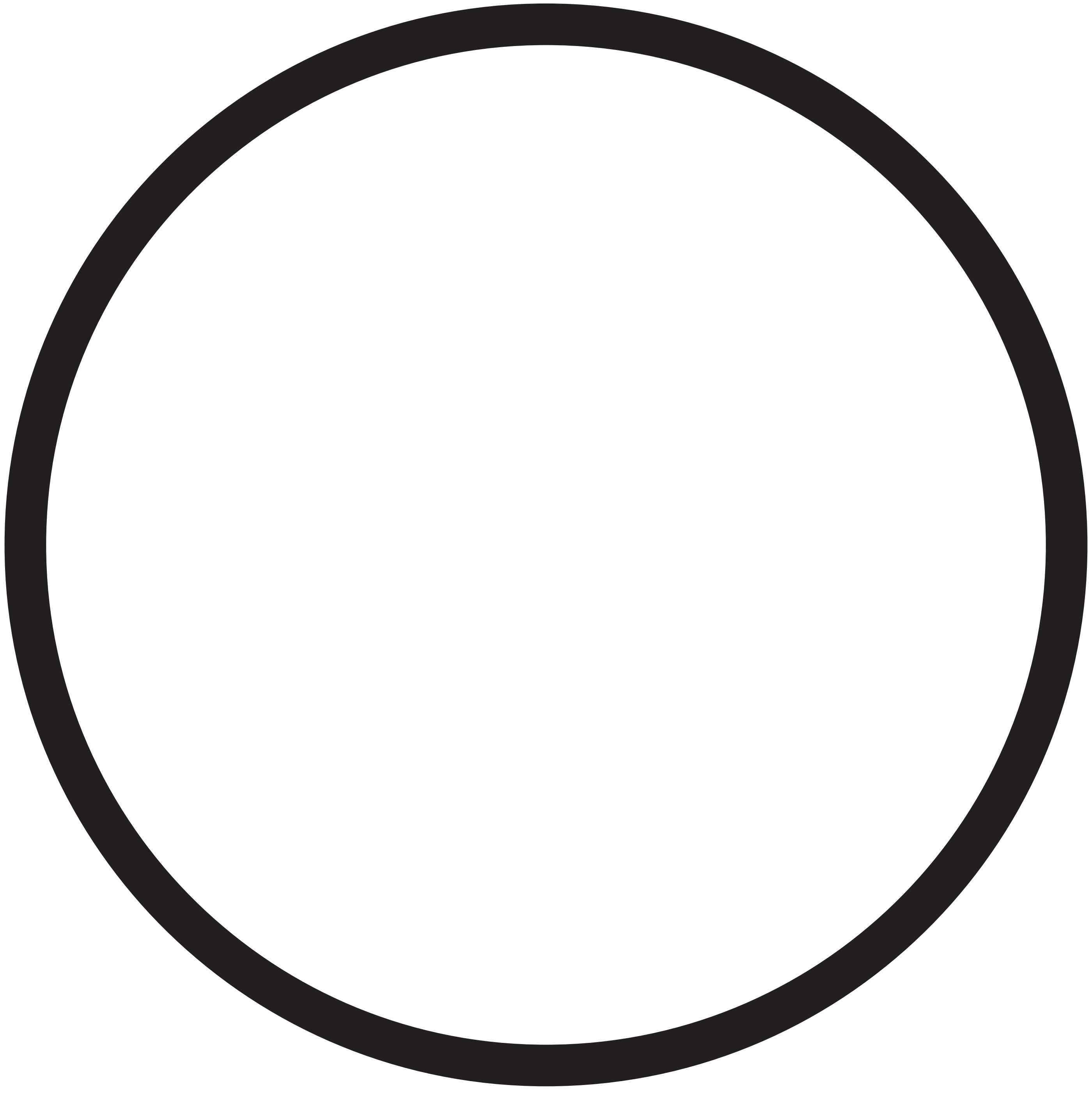


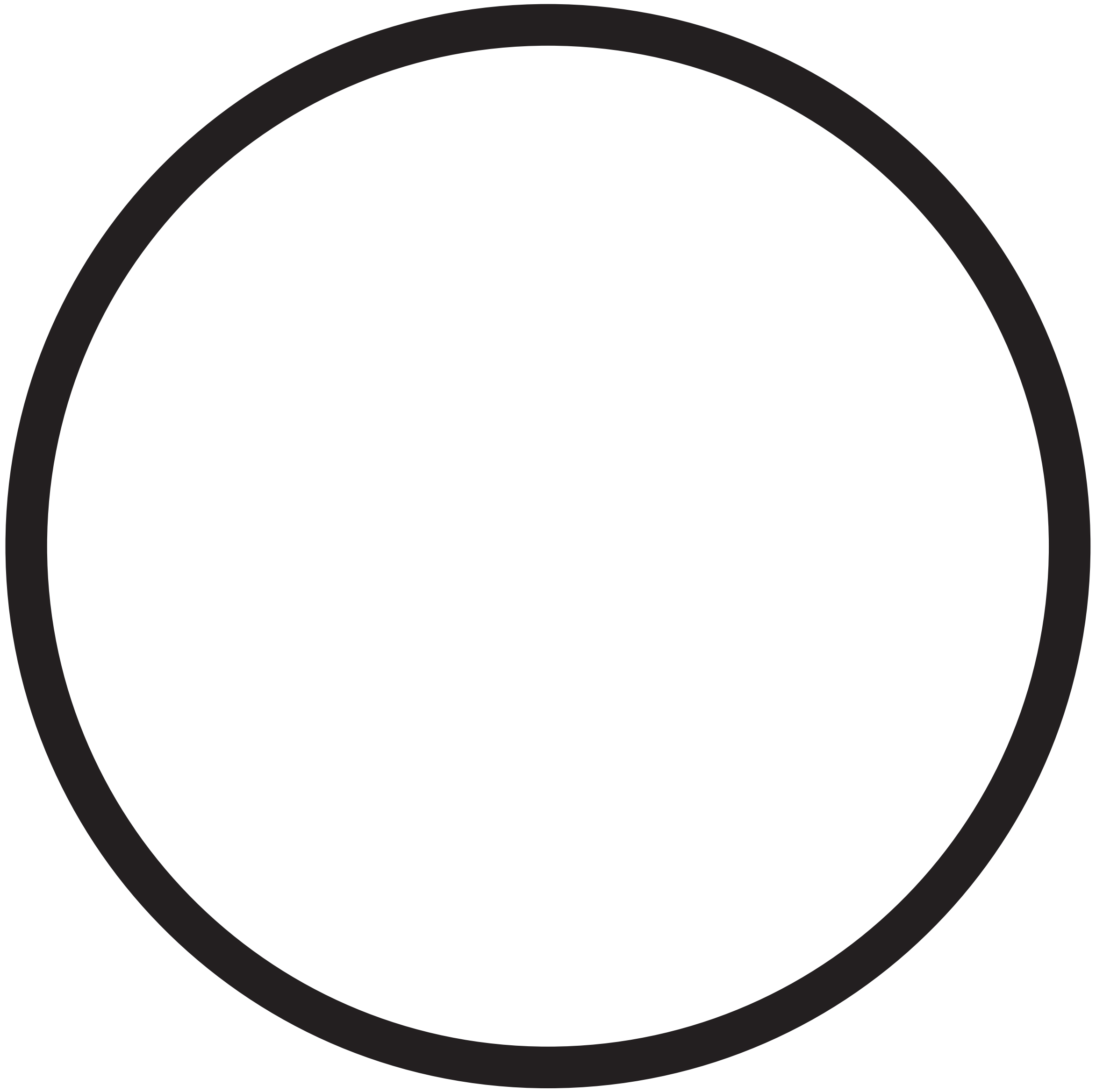
Self collisions : Can we use level sets?



Self collisions : Can we use level sets?





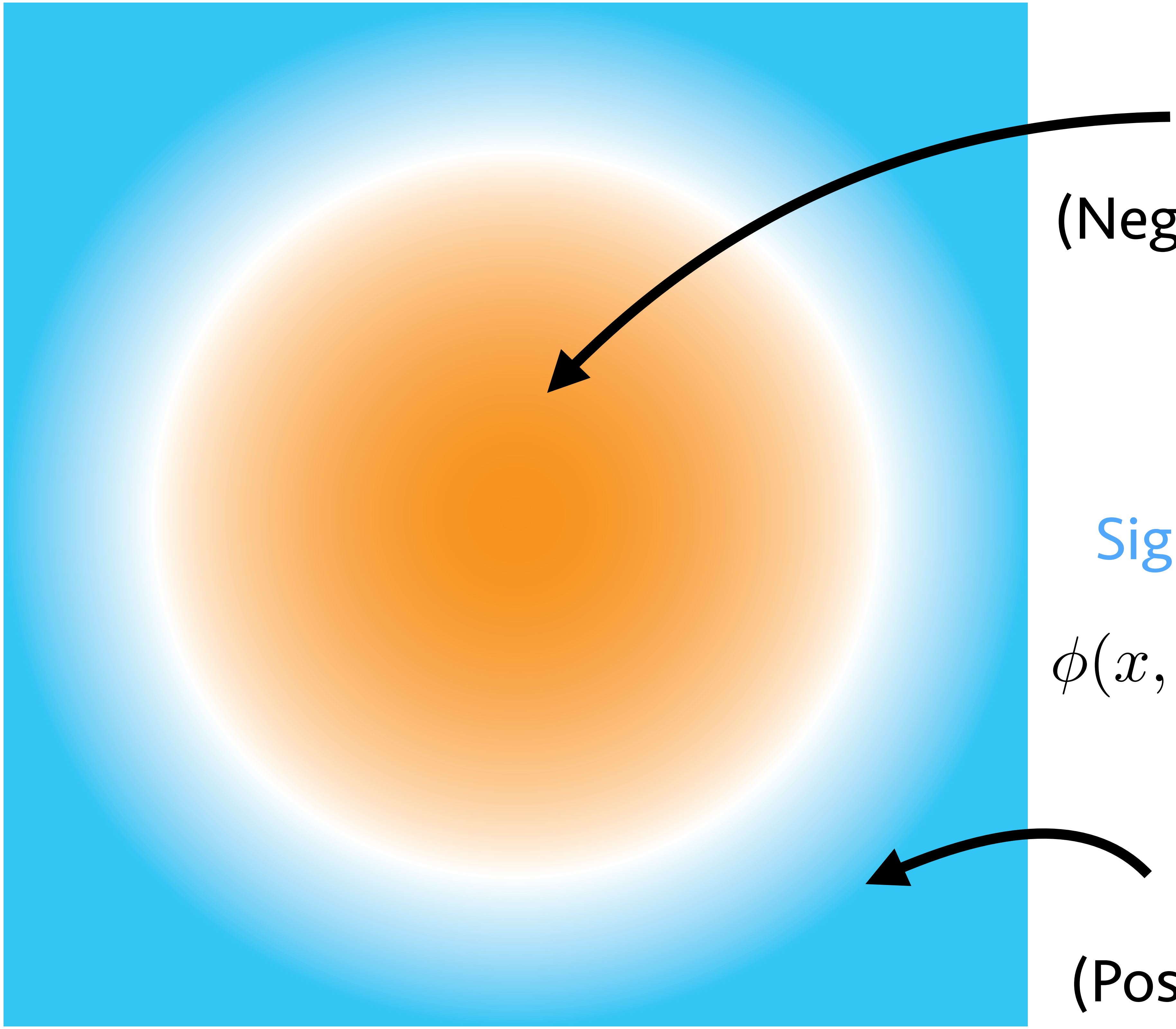


Implicit Surface

$$\mathcal{C} = \{(x,y)|\phi(x,y) = 0\}$$

Signed Distance Field

$$\phi(x,y) = \sqrt{x^2 + y^2} - 1$$



Inside

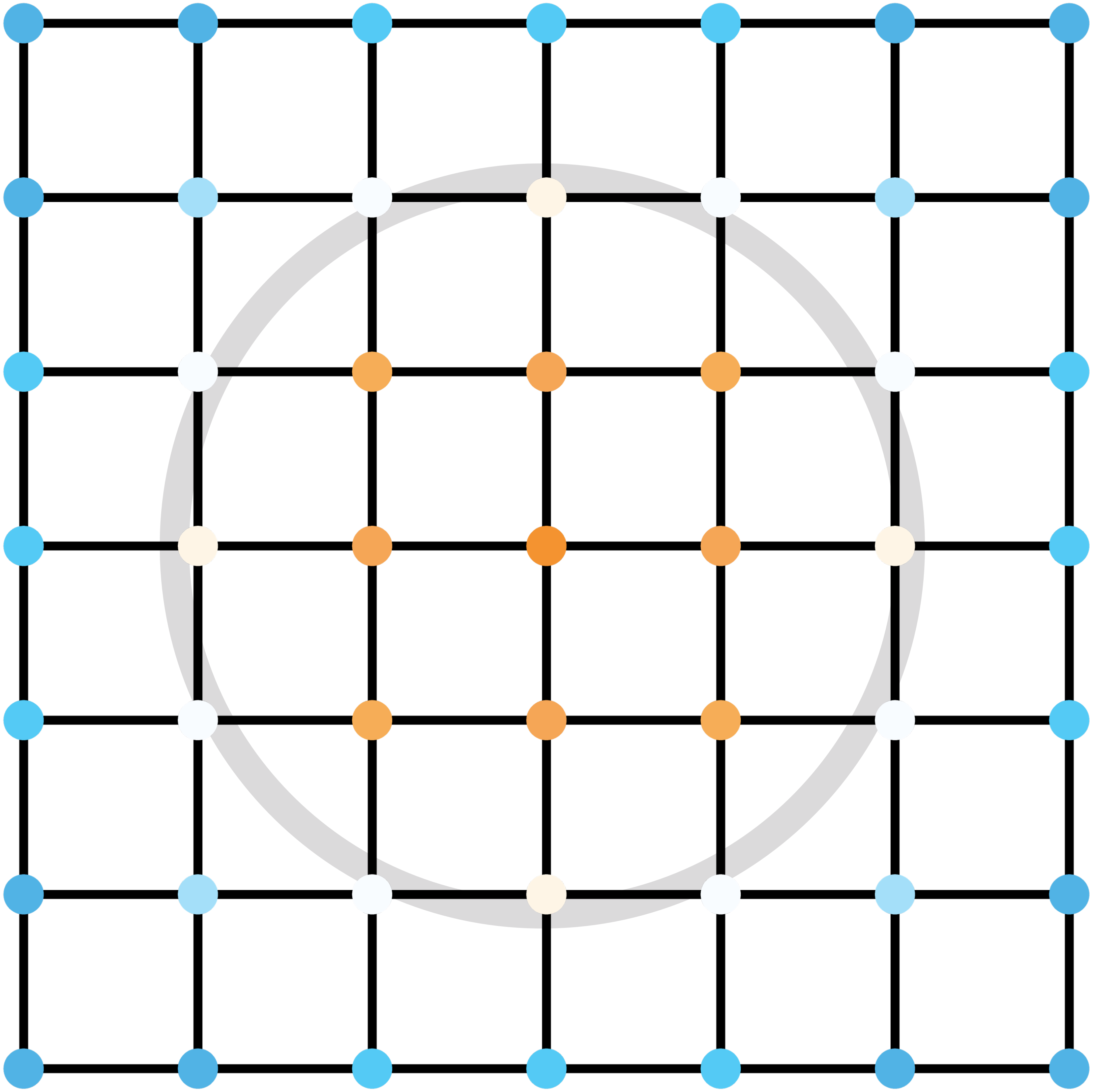
(Negative Φ Values)

Signed Distance Field

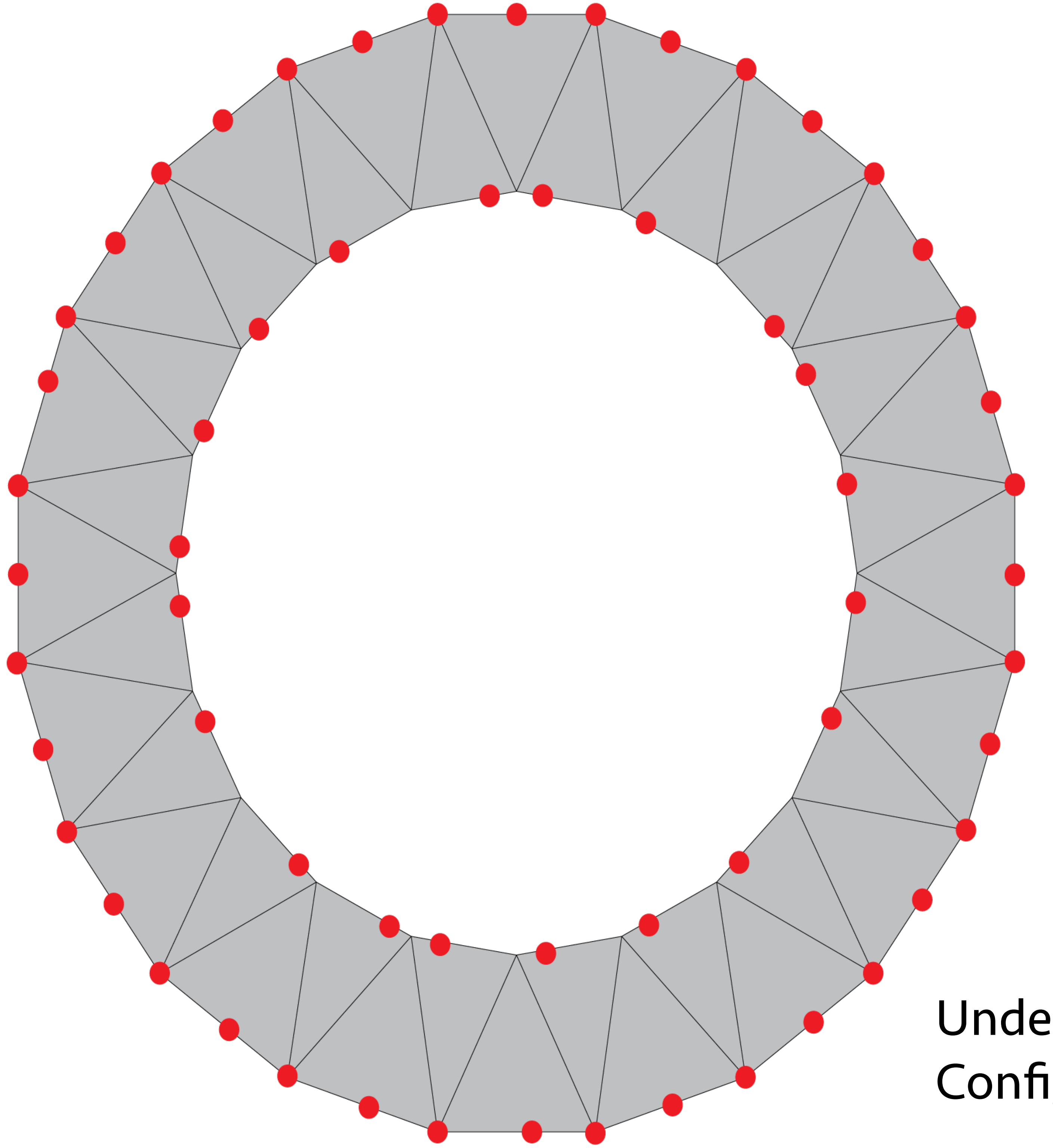
$$\phi(x, y) = \sqrt{x^2 + y^2} - 1$$

Outside

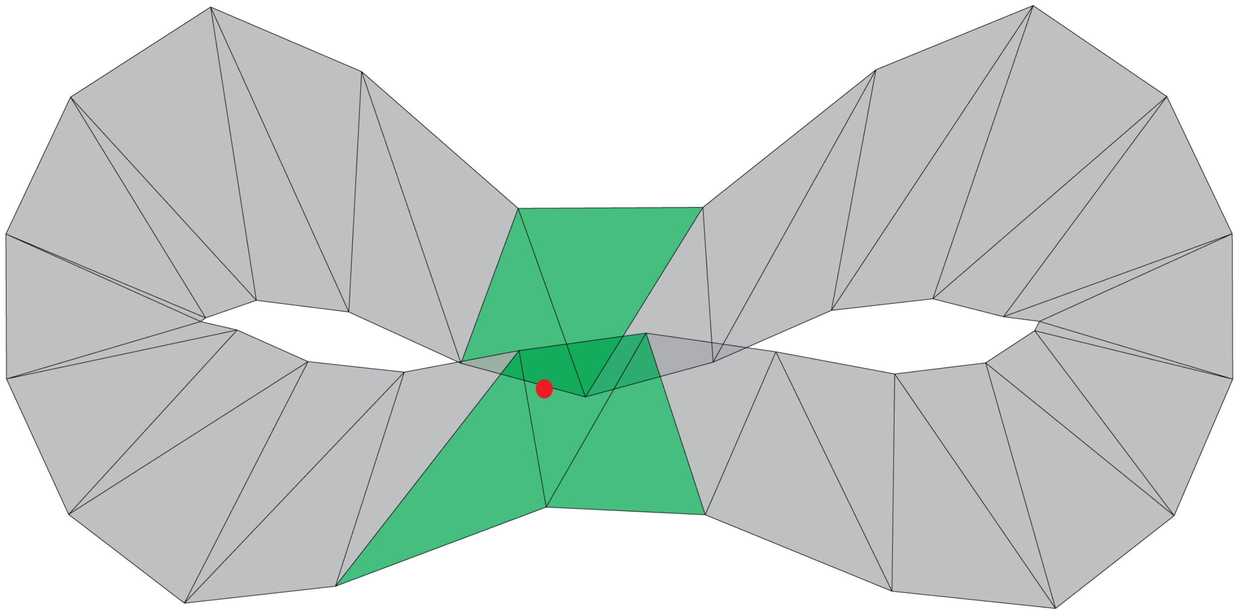
(Positive Φ Values)



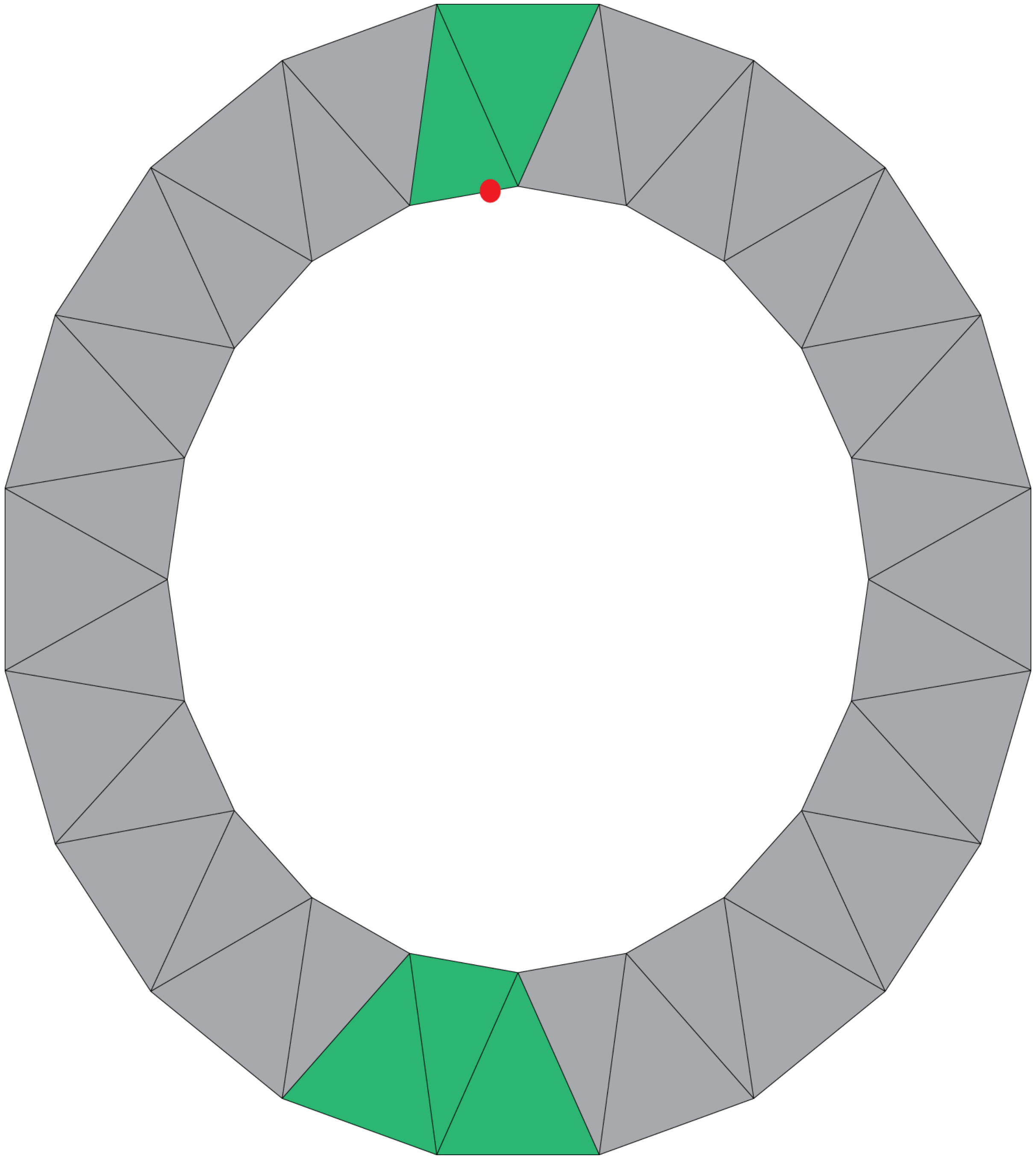
Discrete
Signed Distance Field



Undeformed
Configuration



Deformed Configuration



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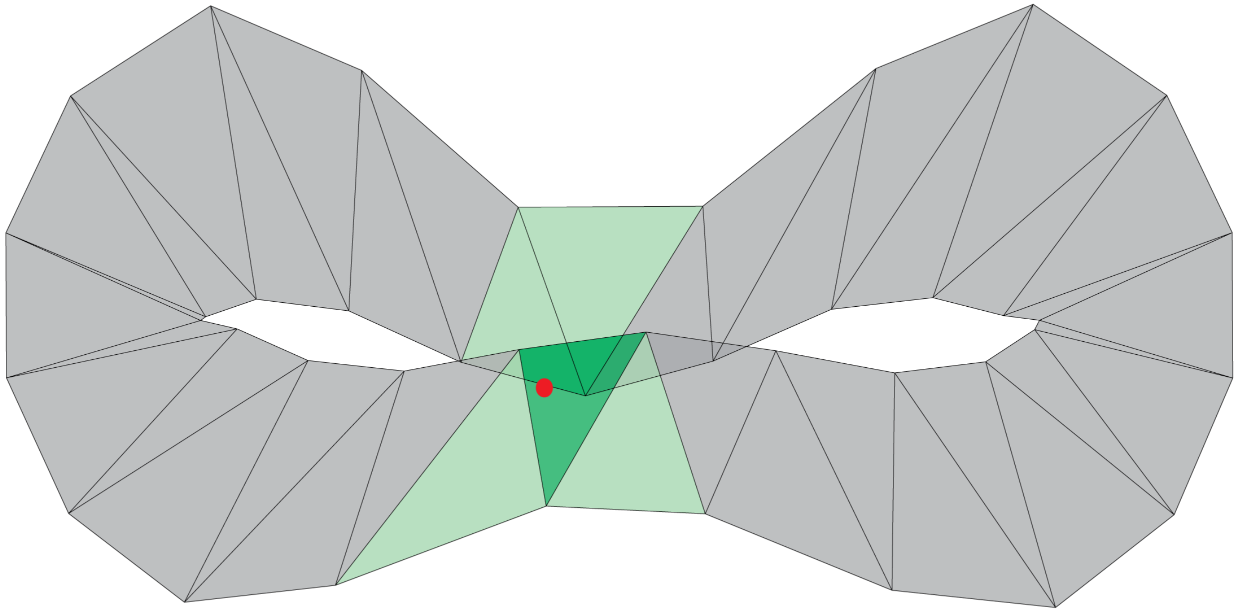

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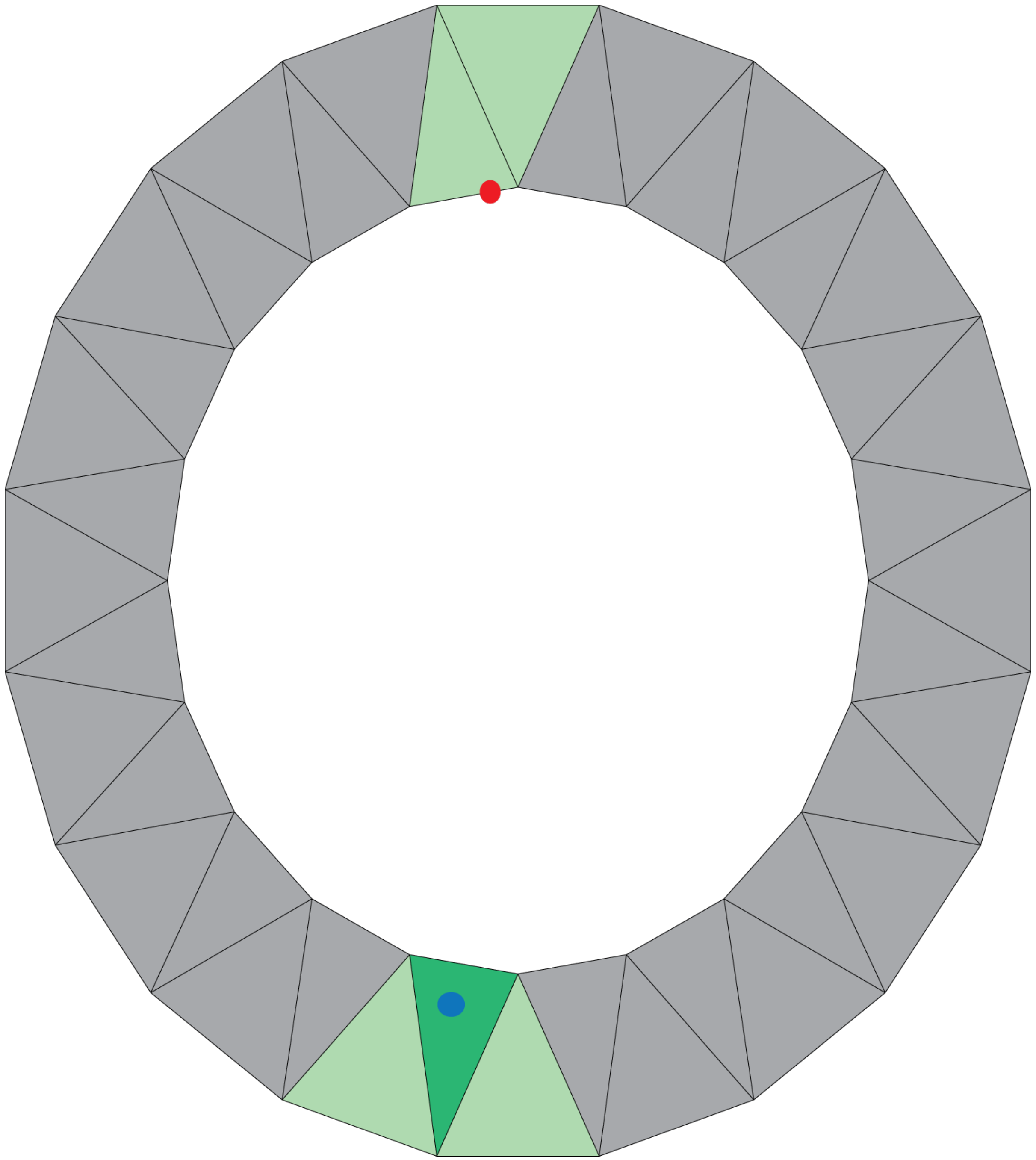

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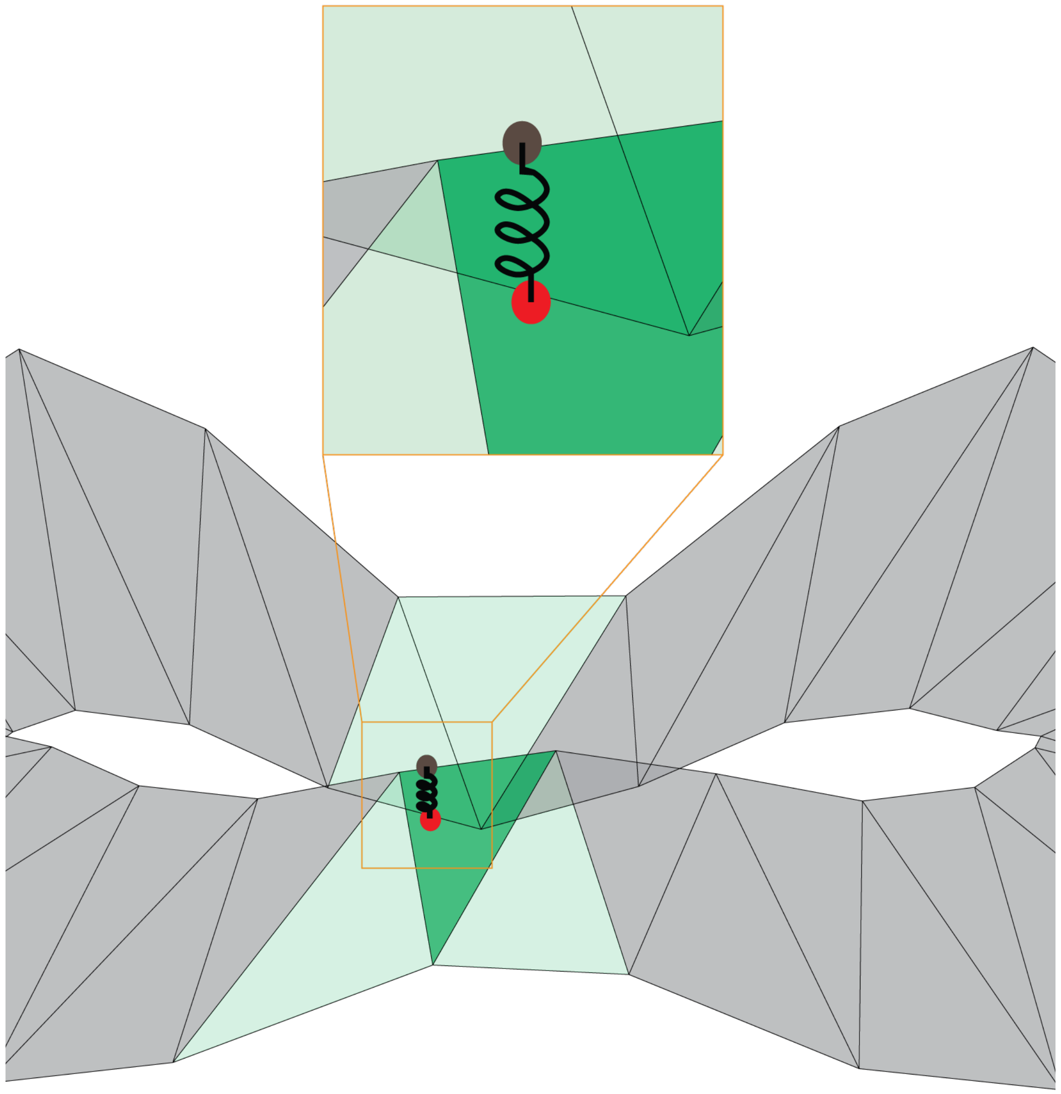

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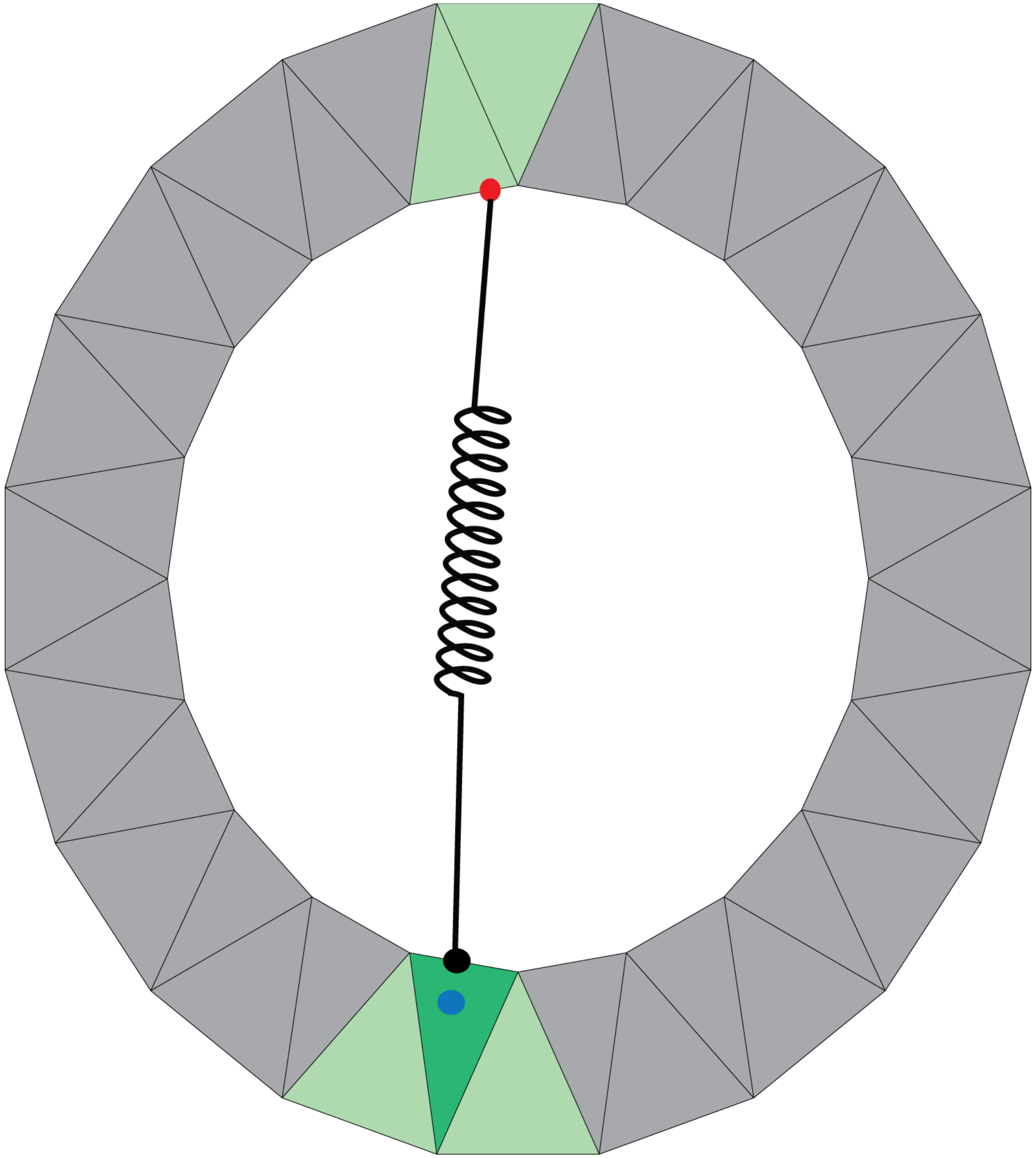

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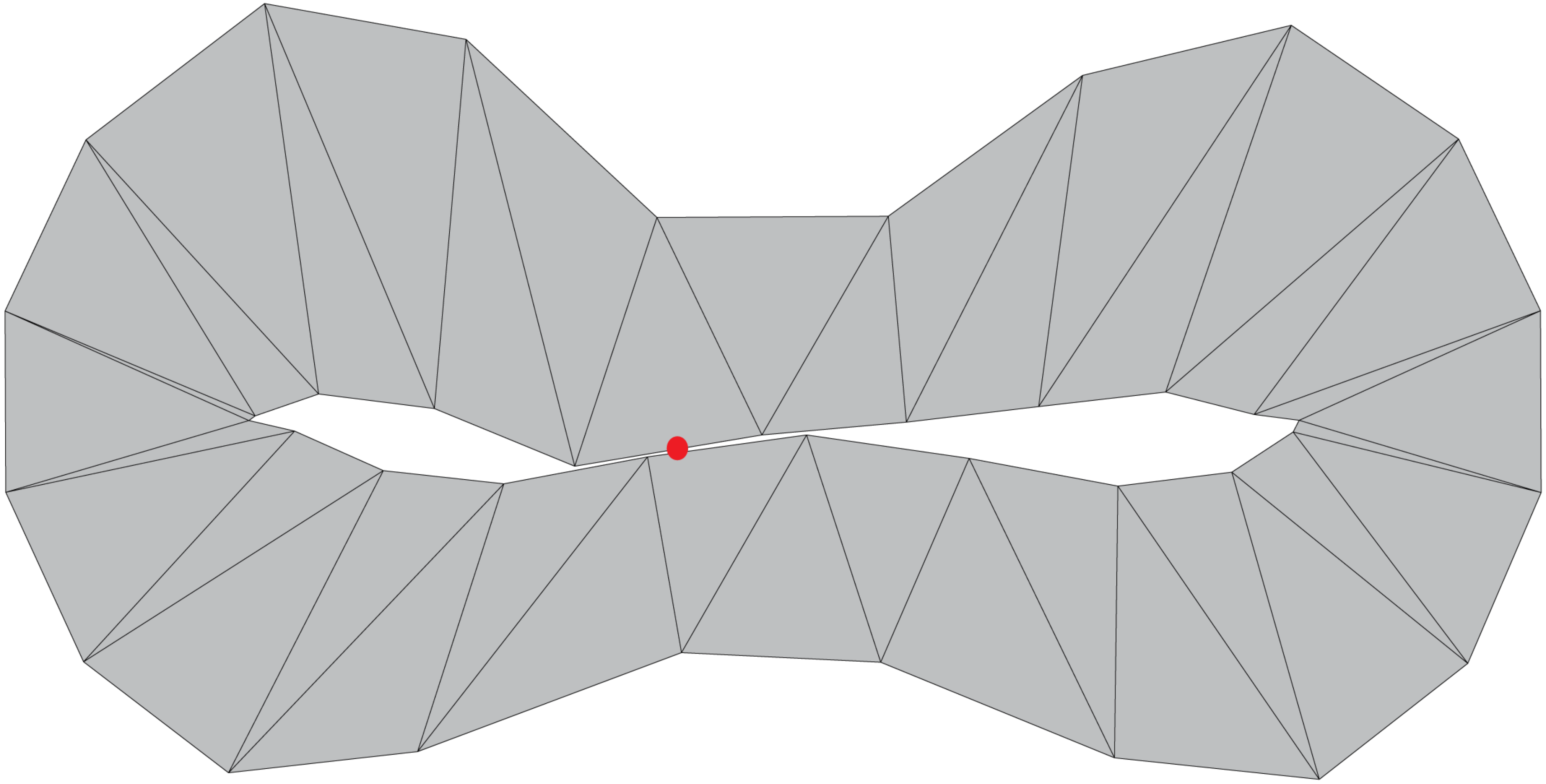
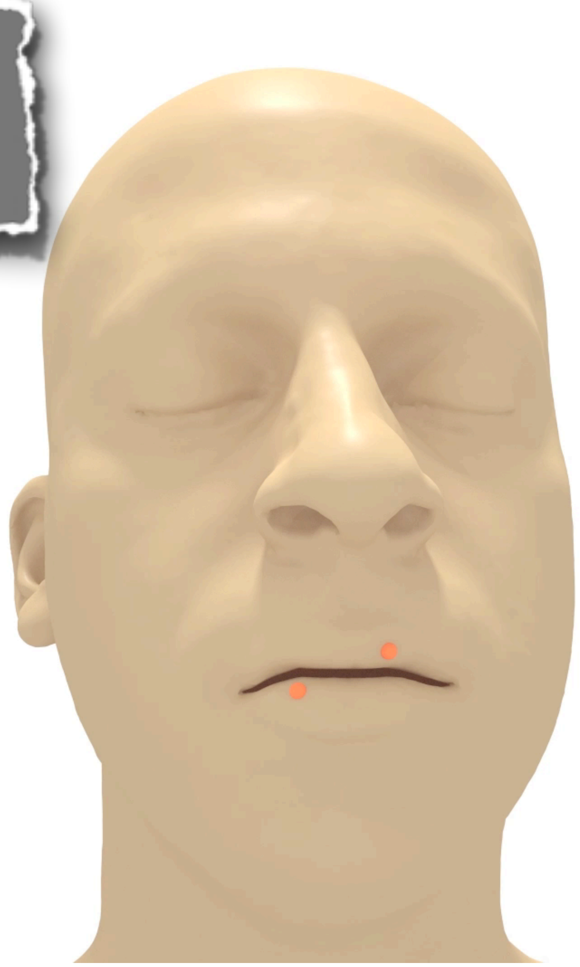
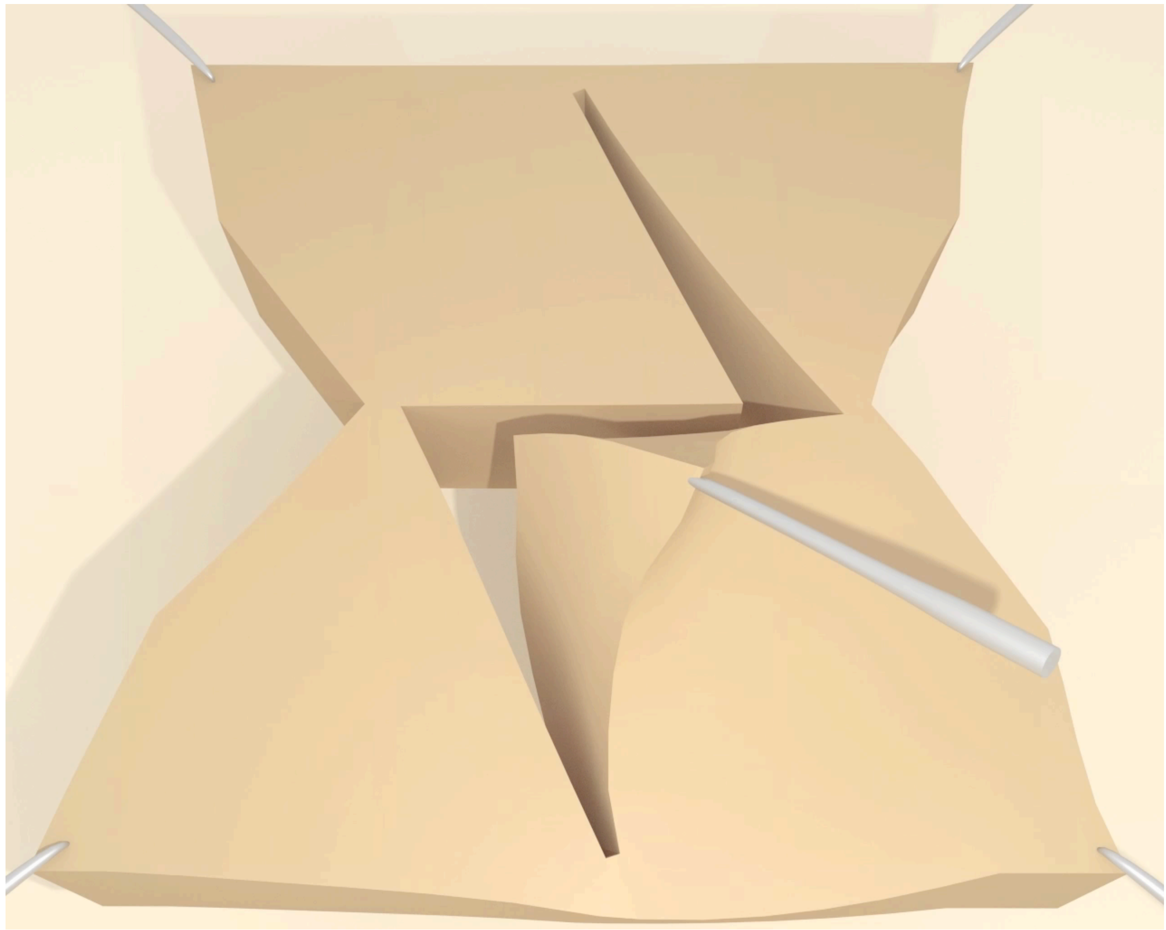
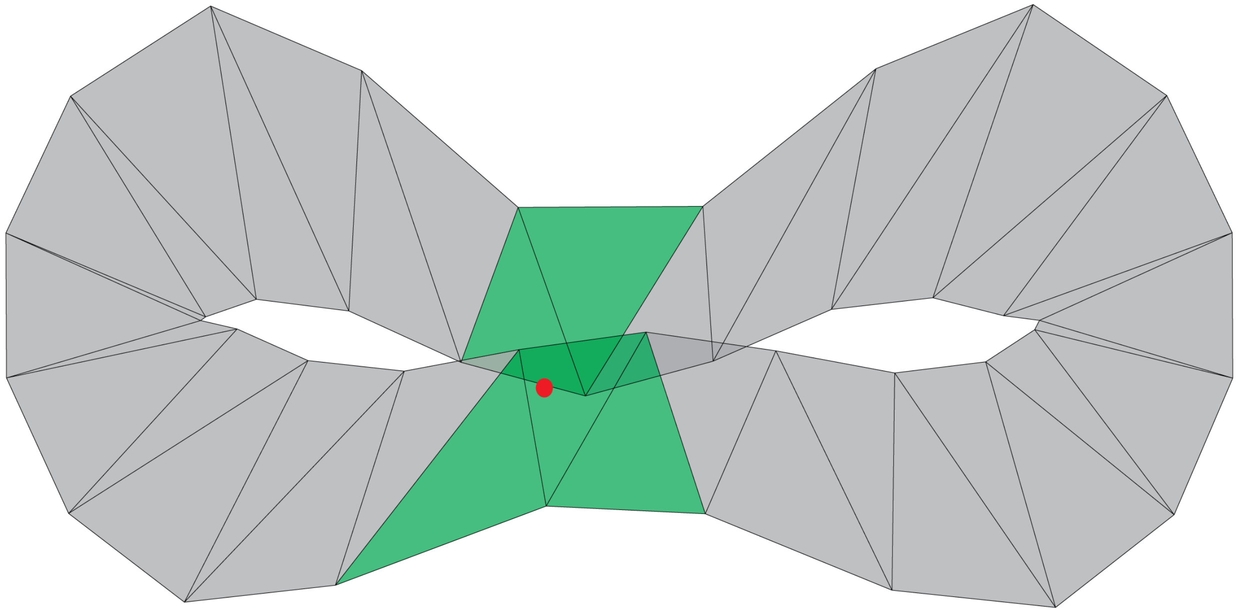


Deformed
Configuration

Problem cases







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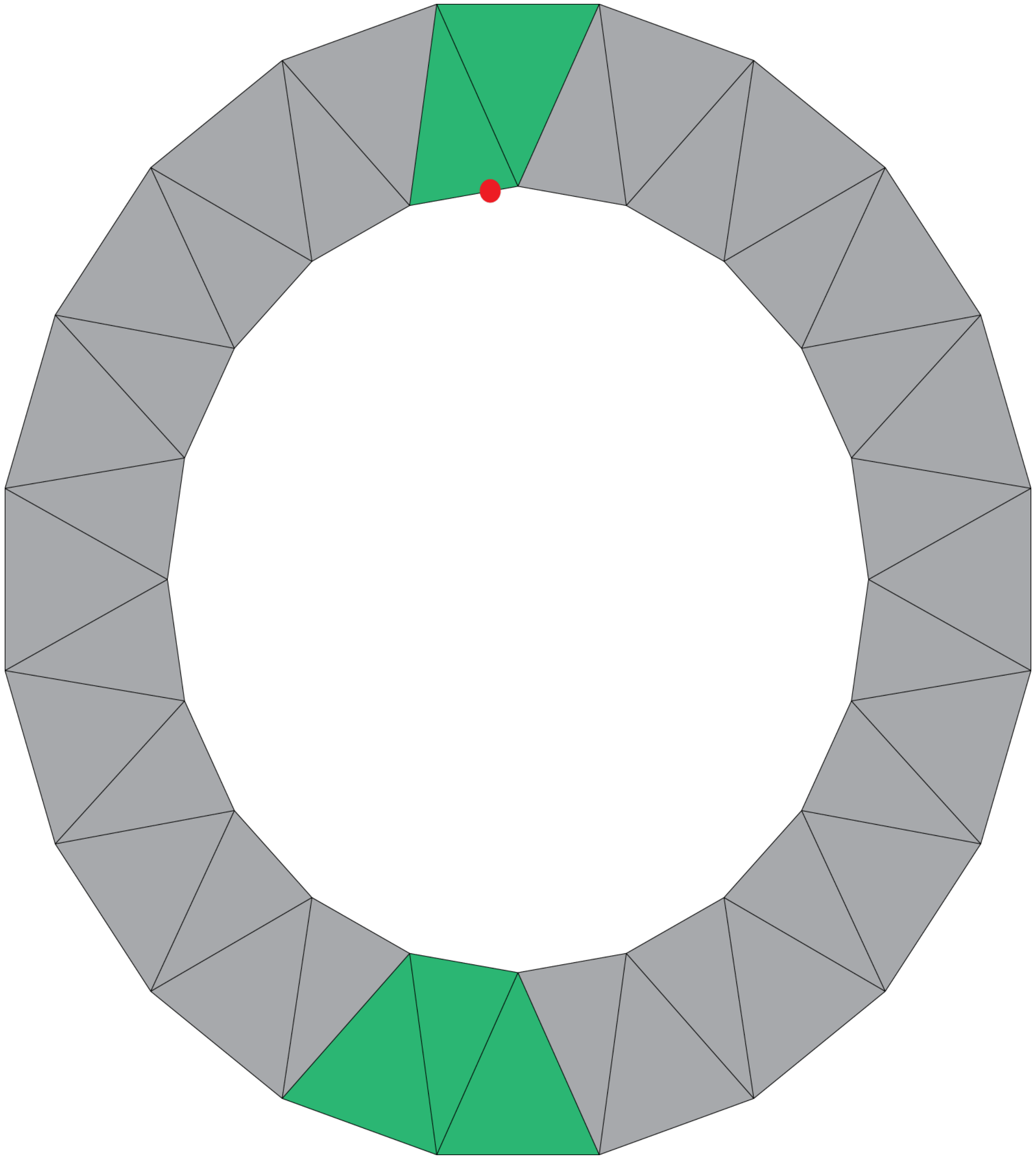

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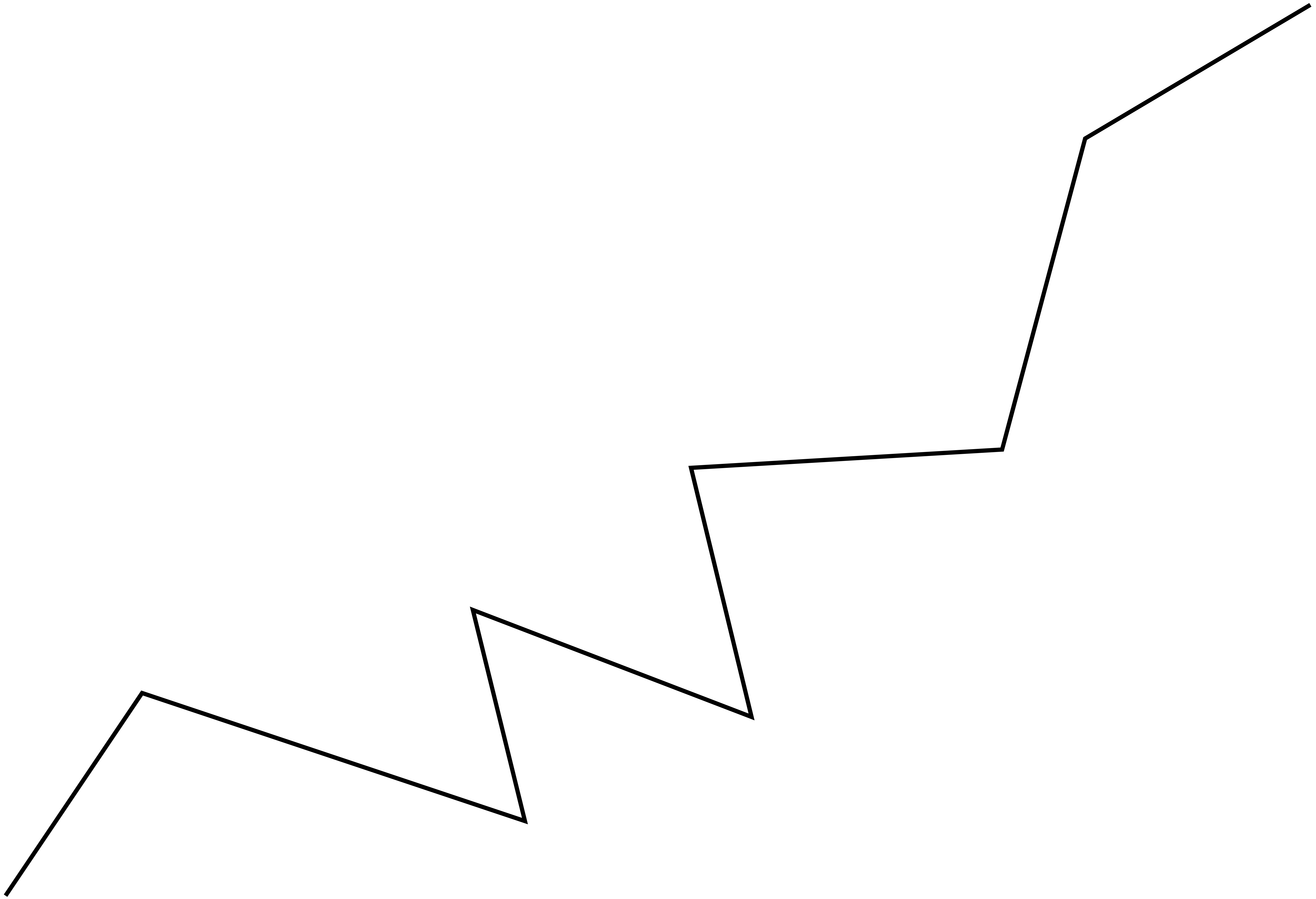

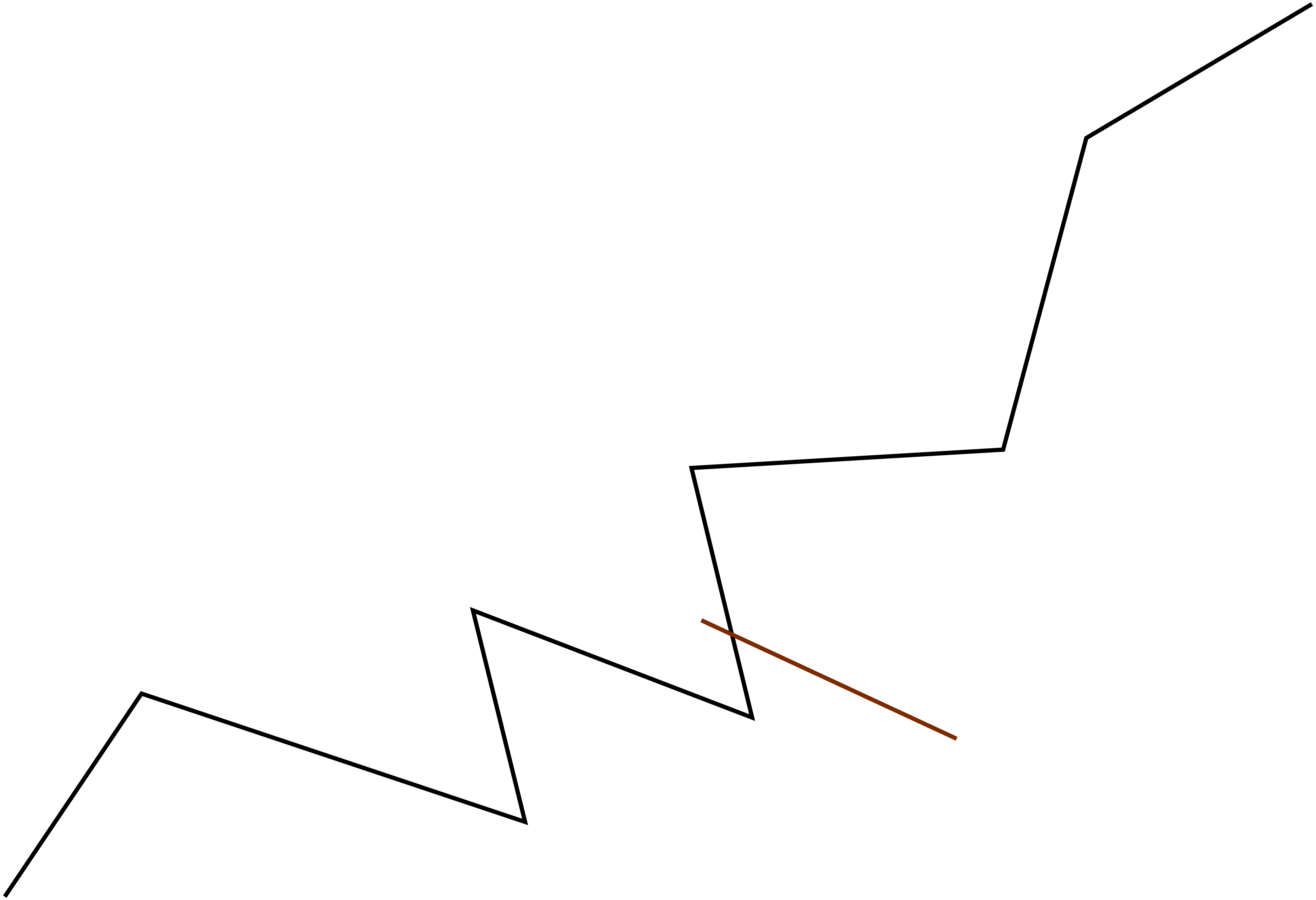

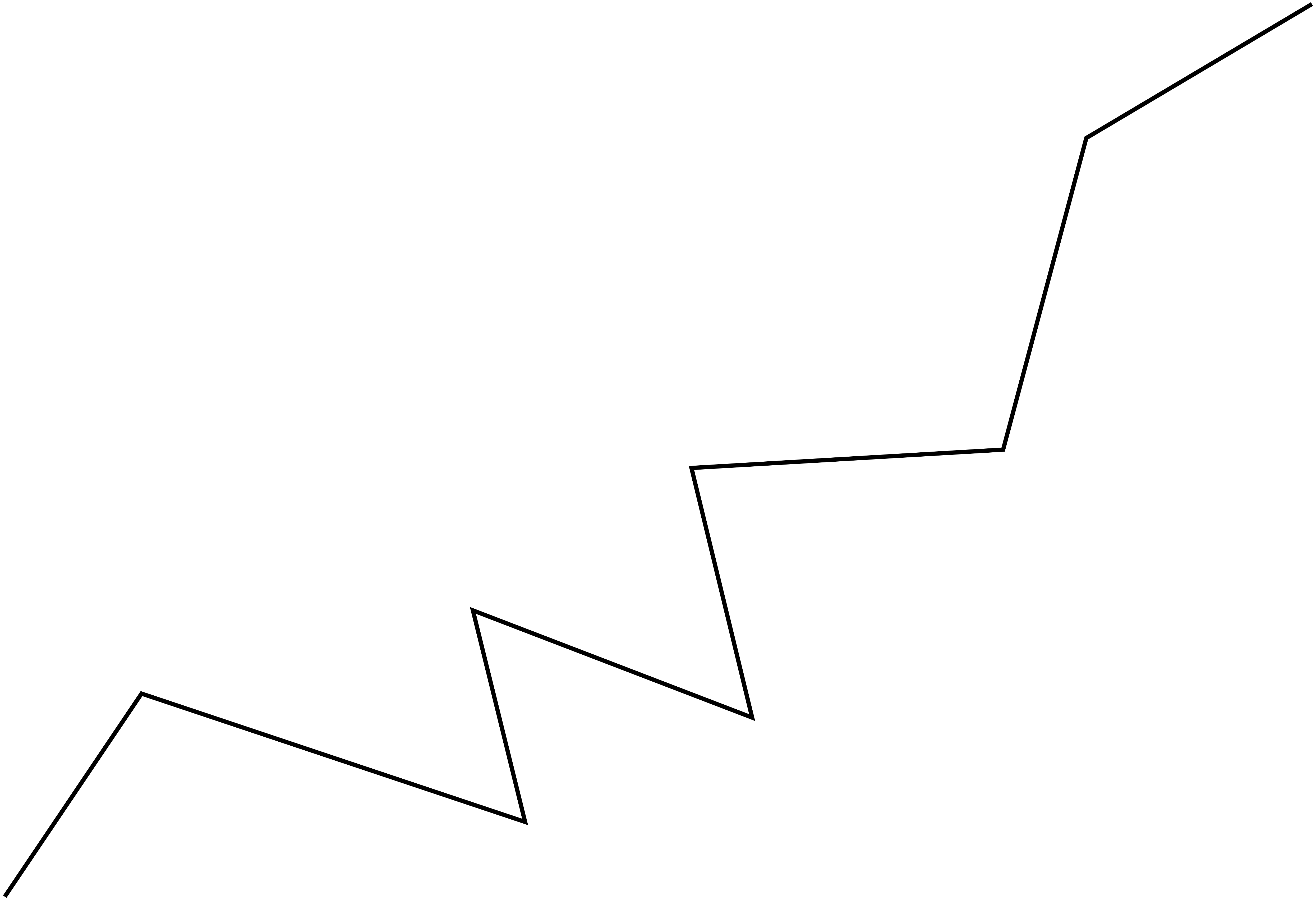

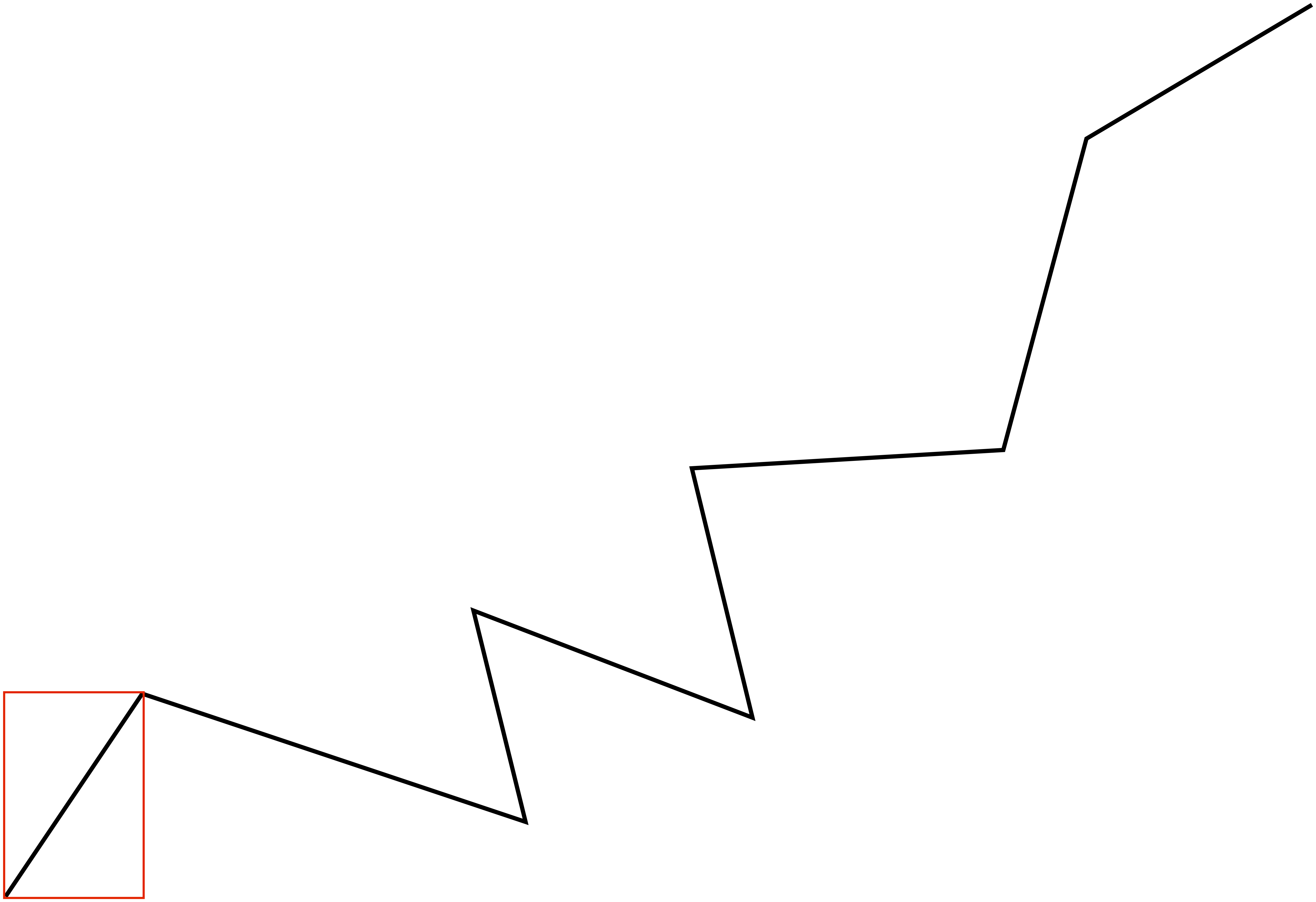

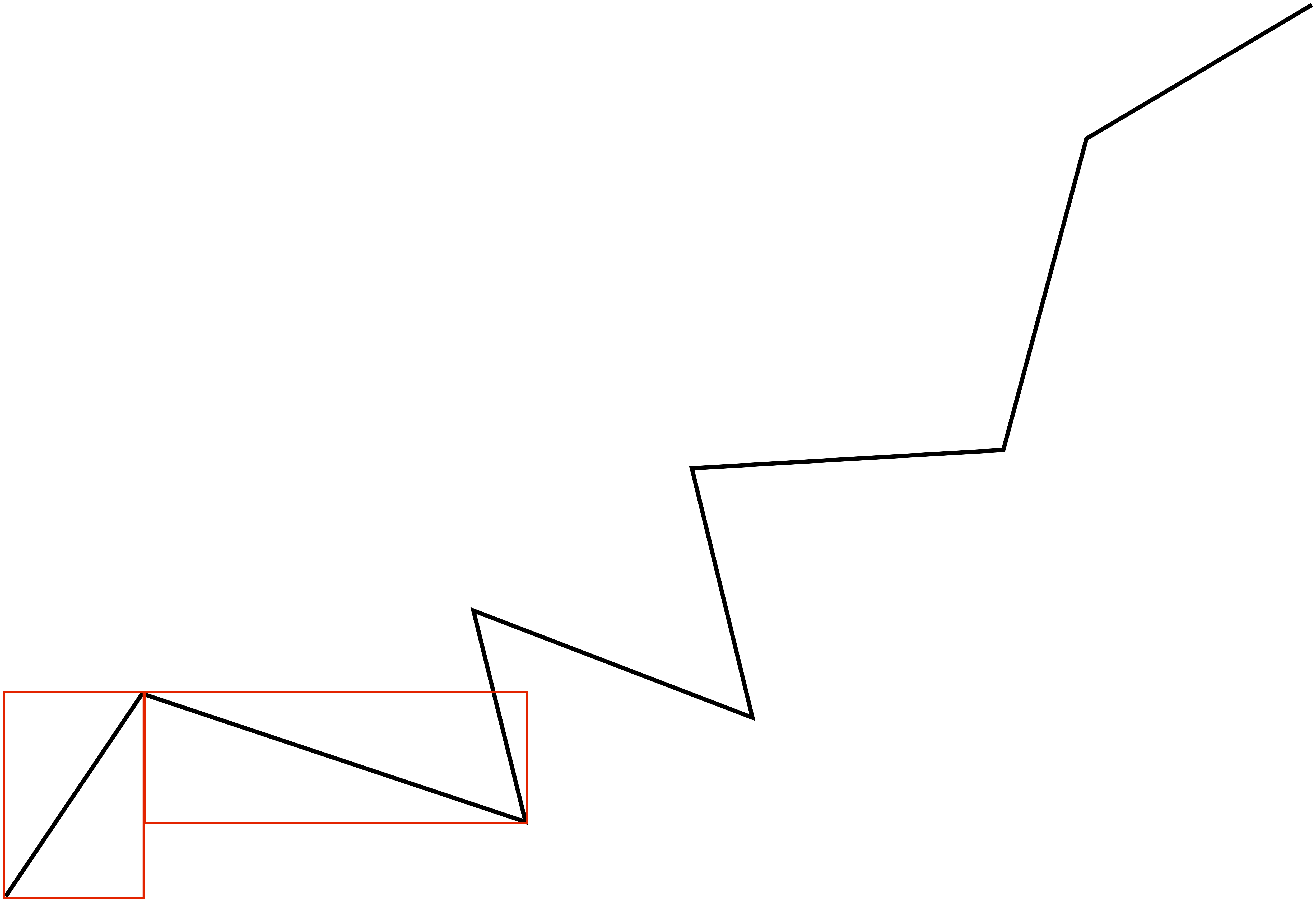

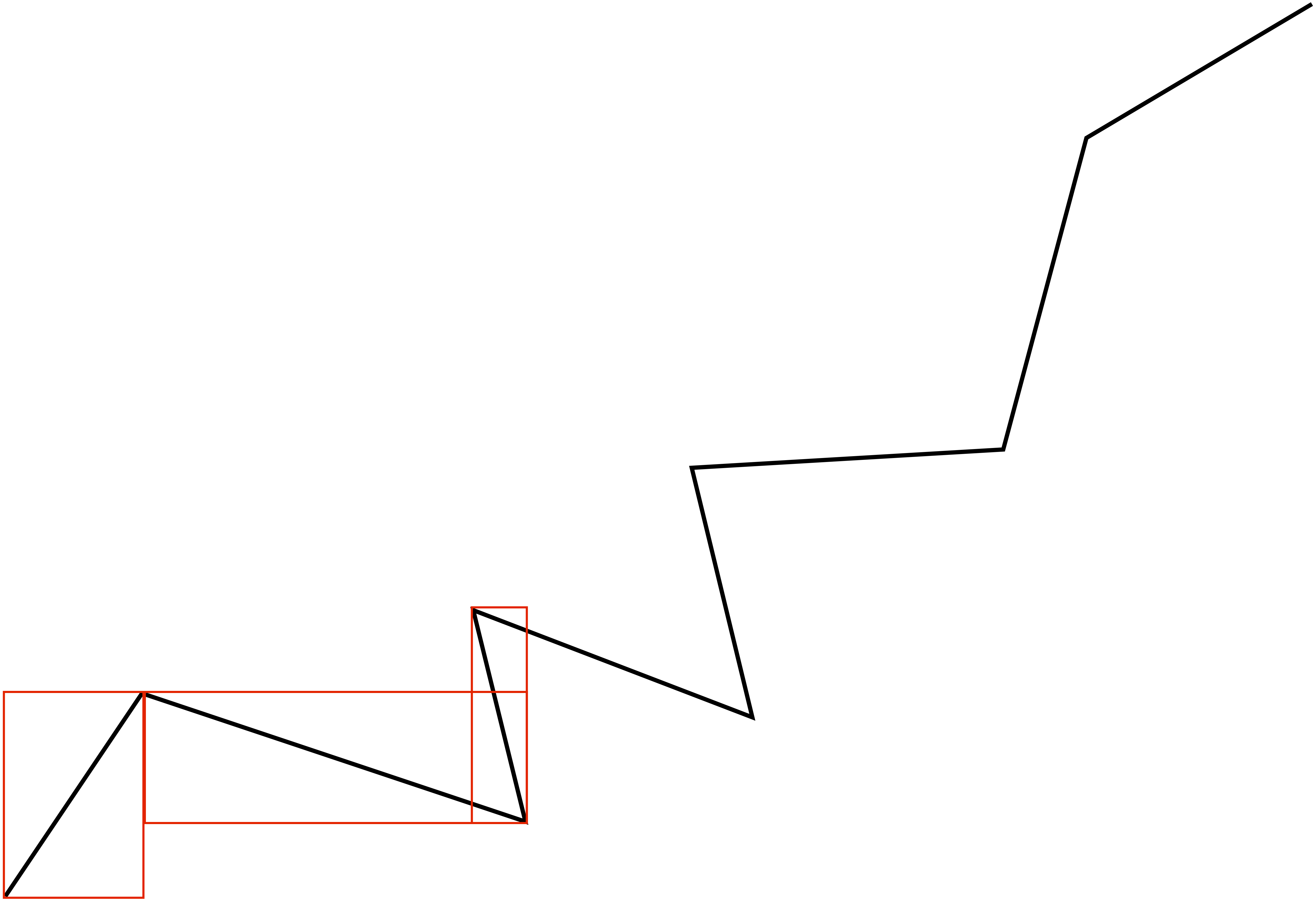

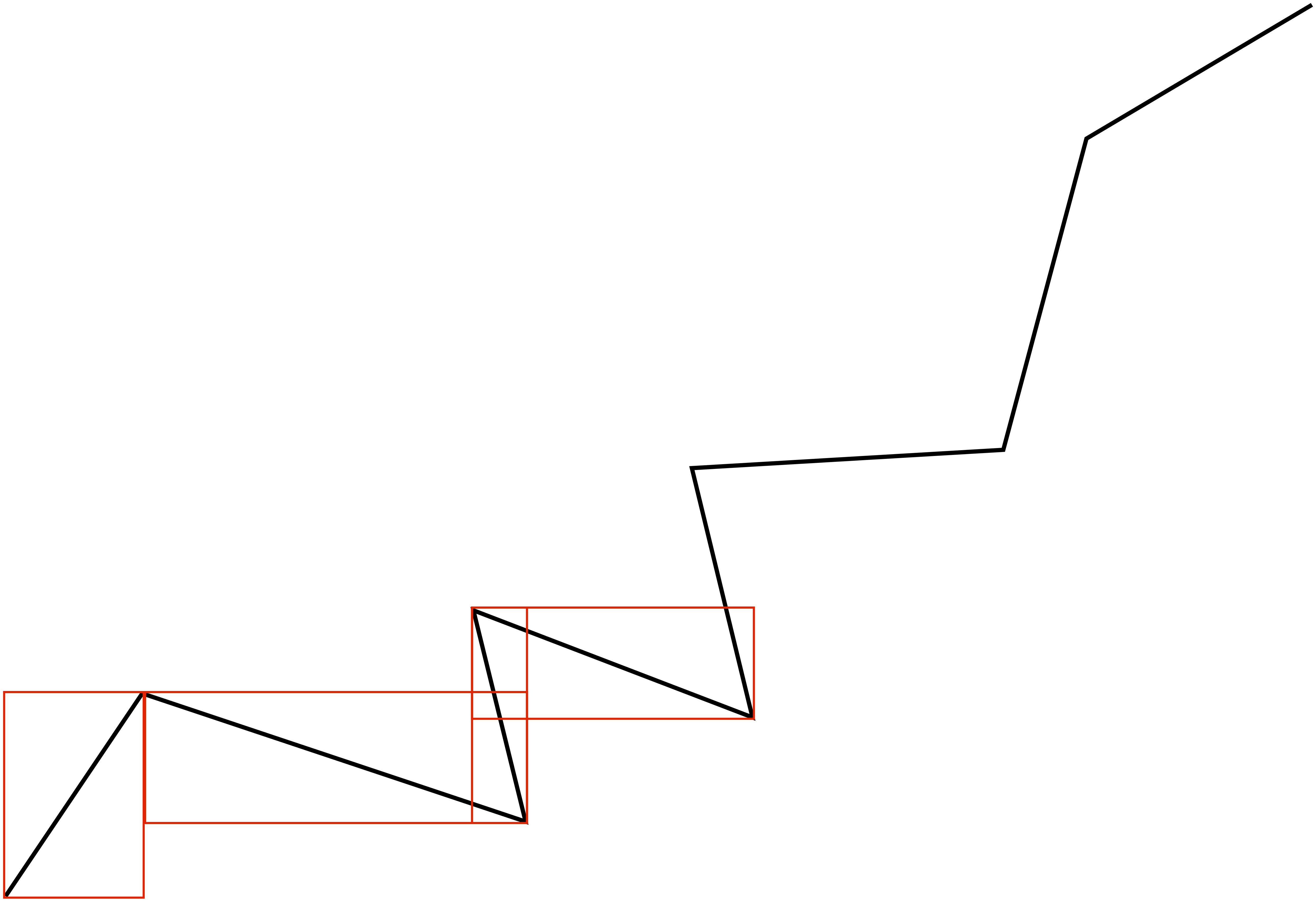

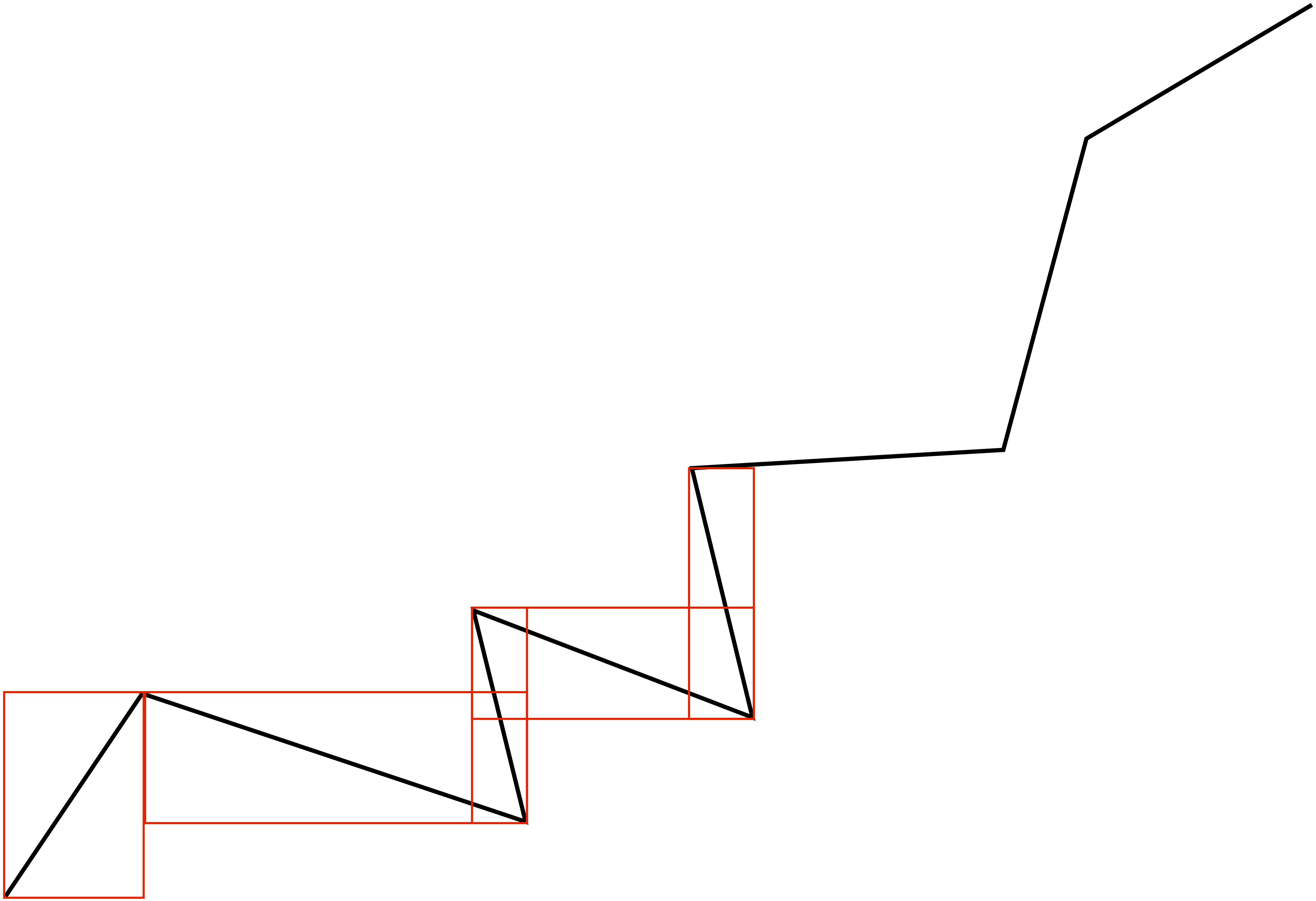

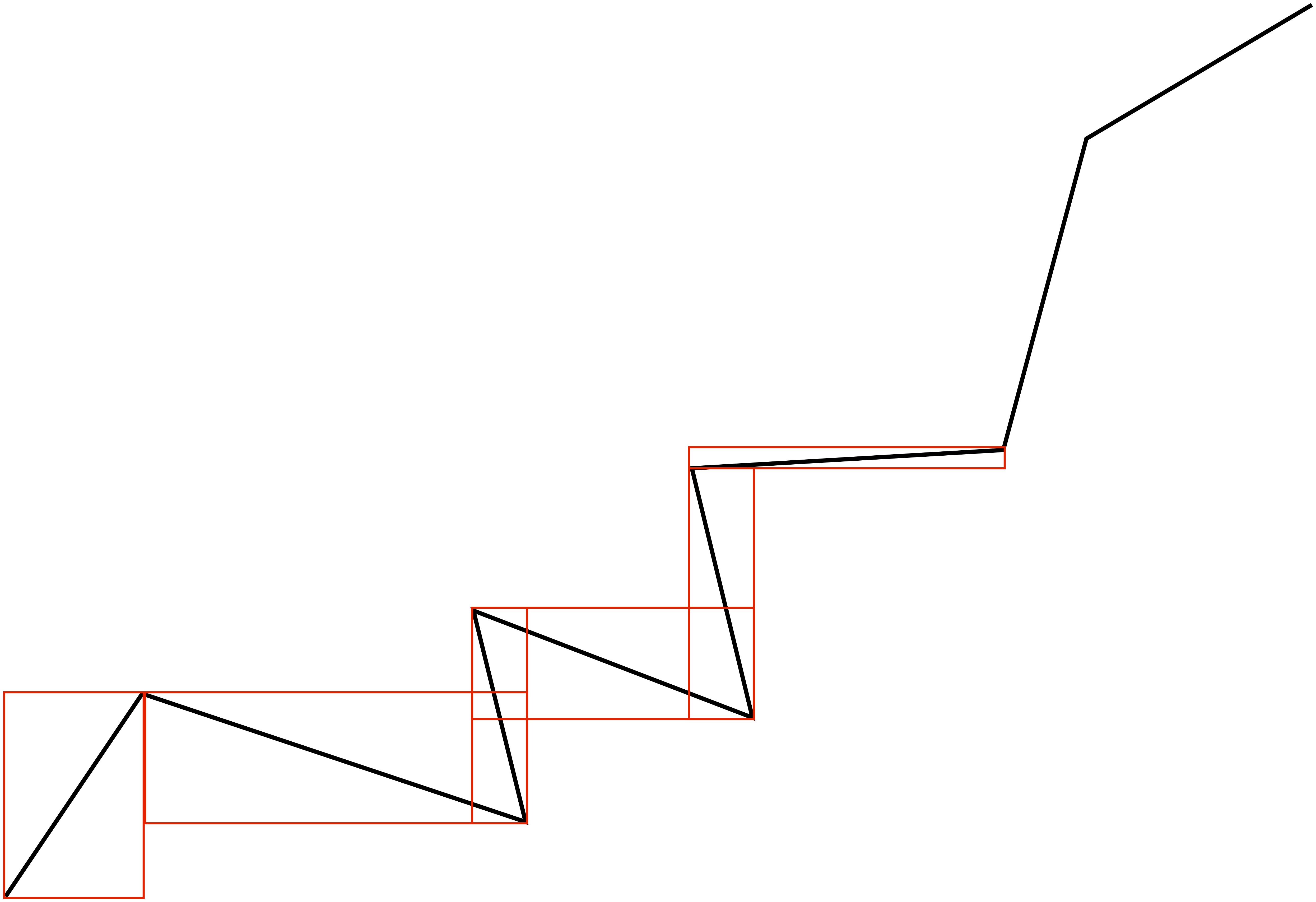

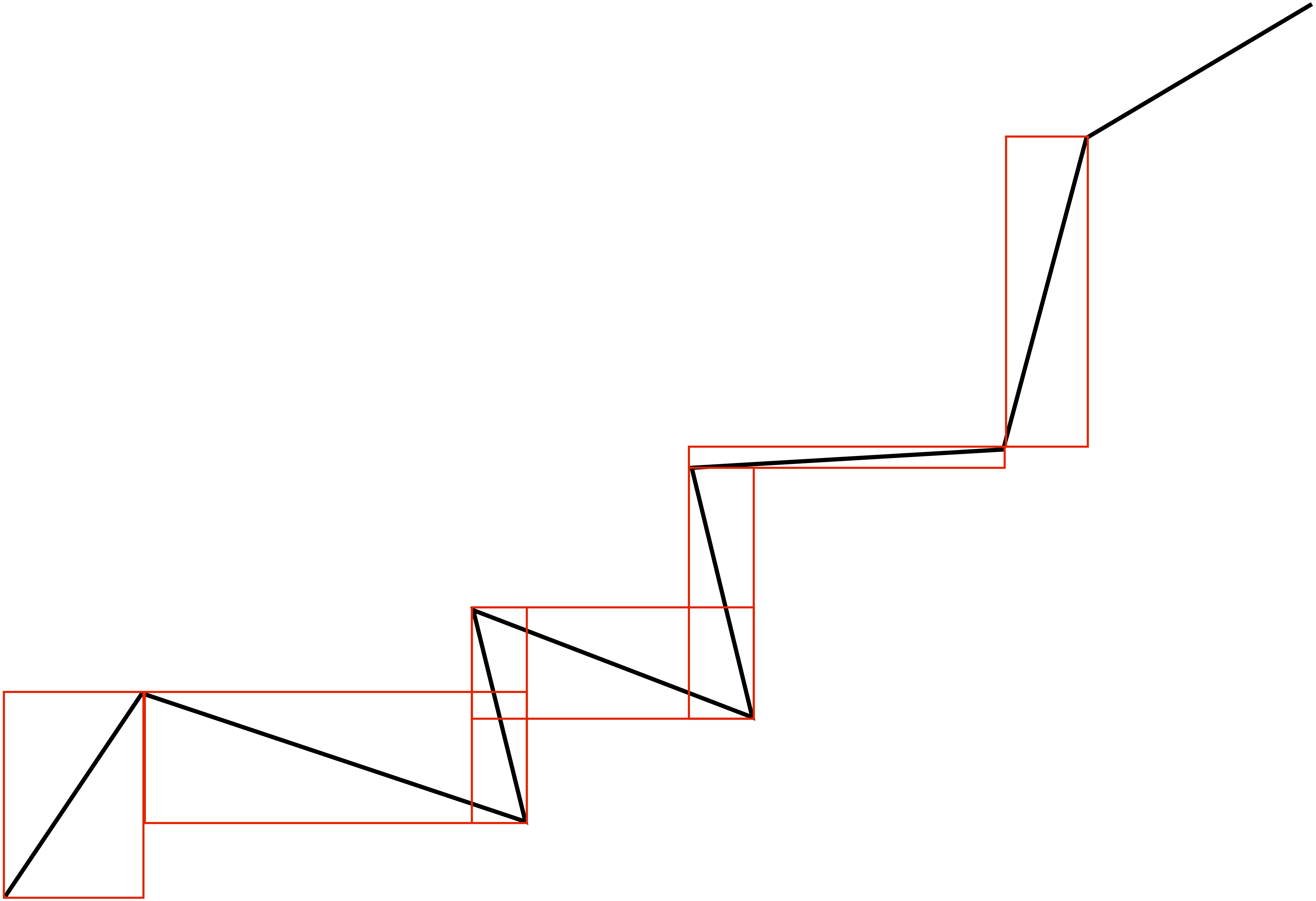

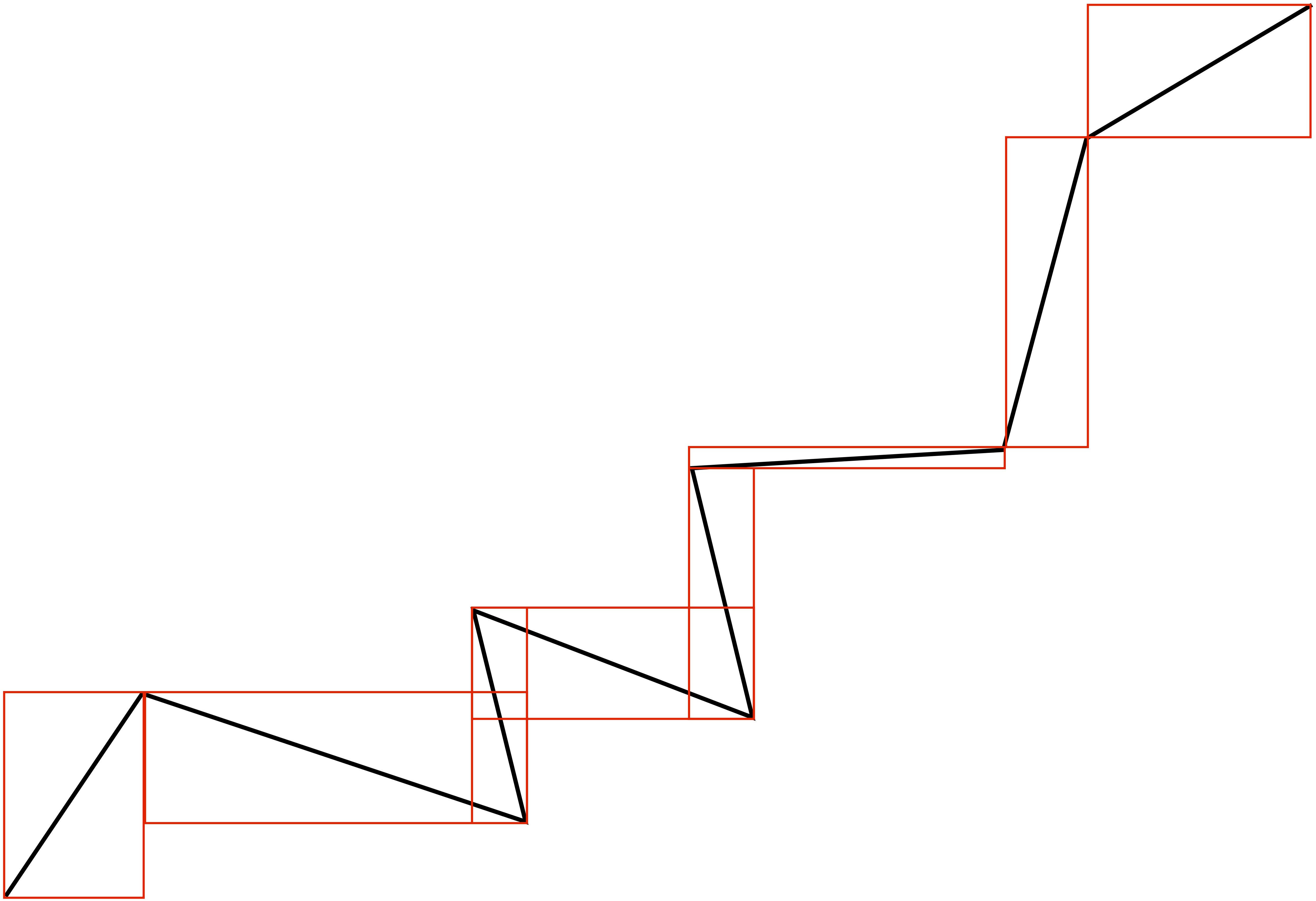

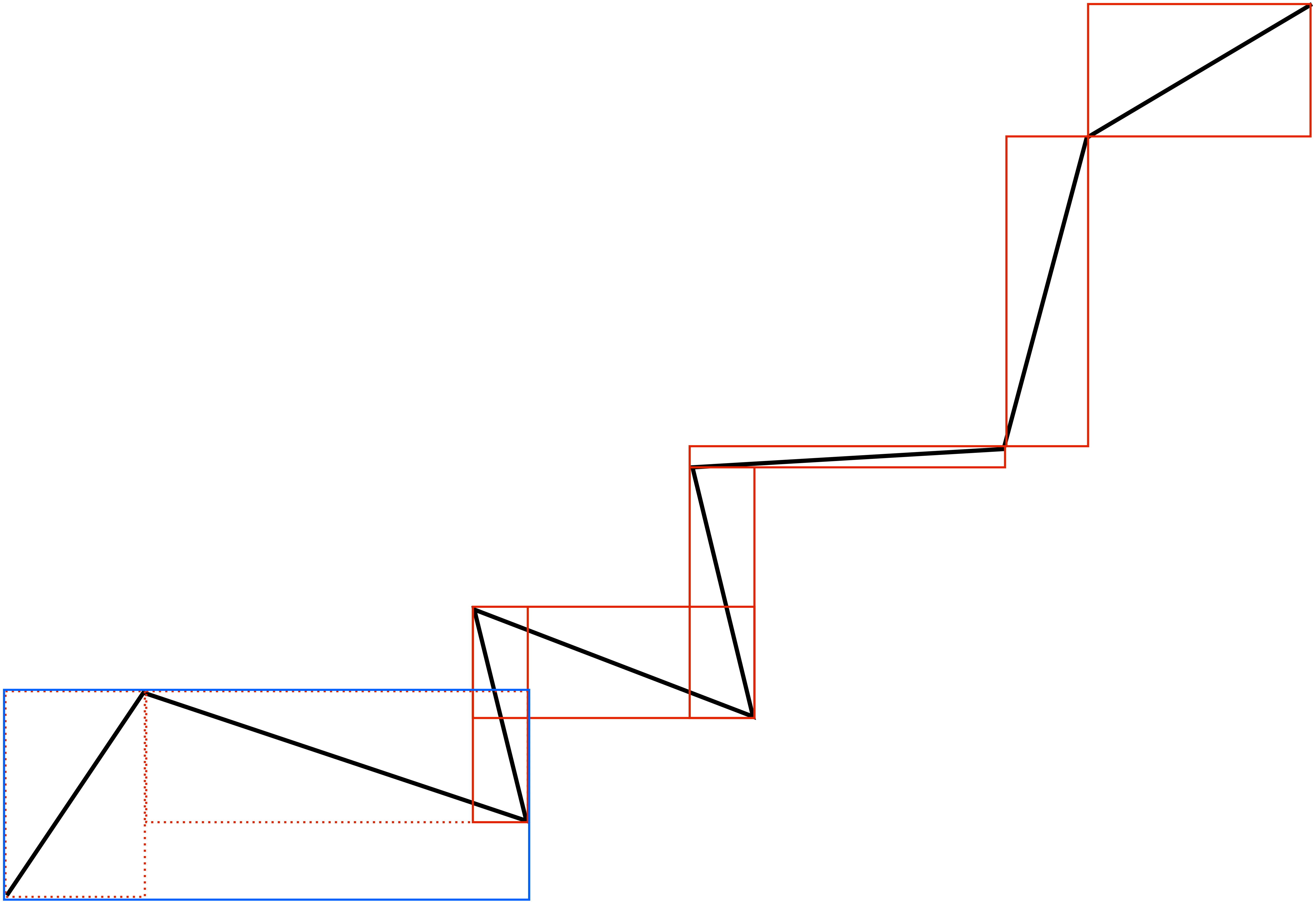

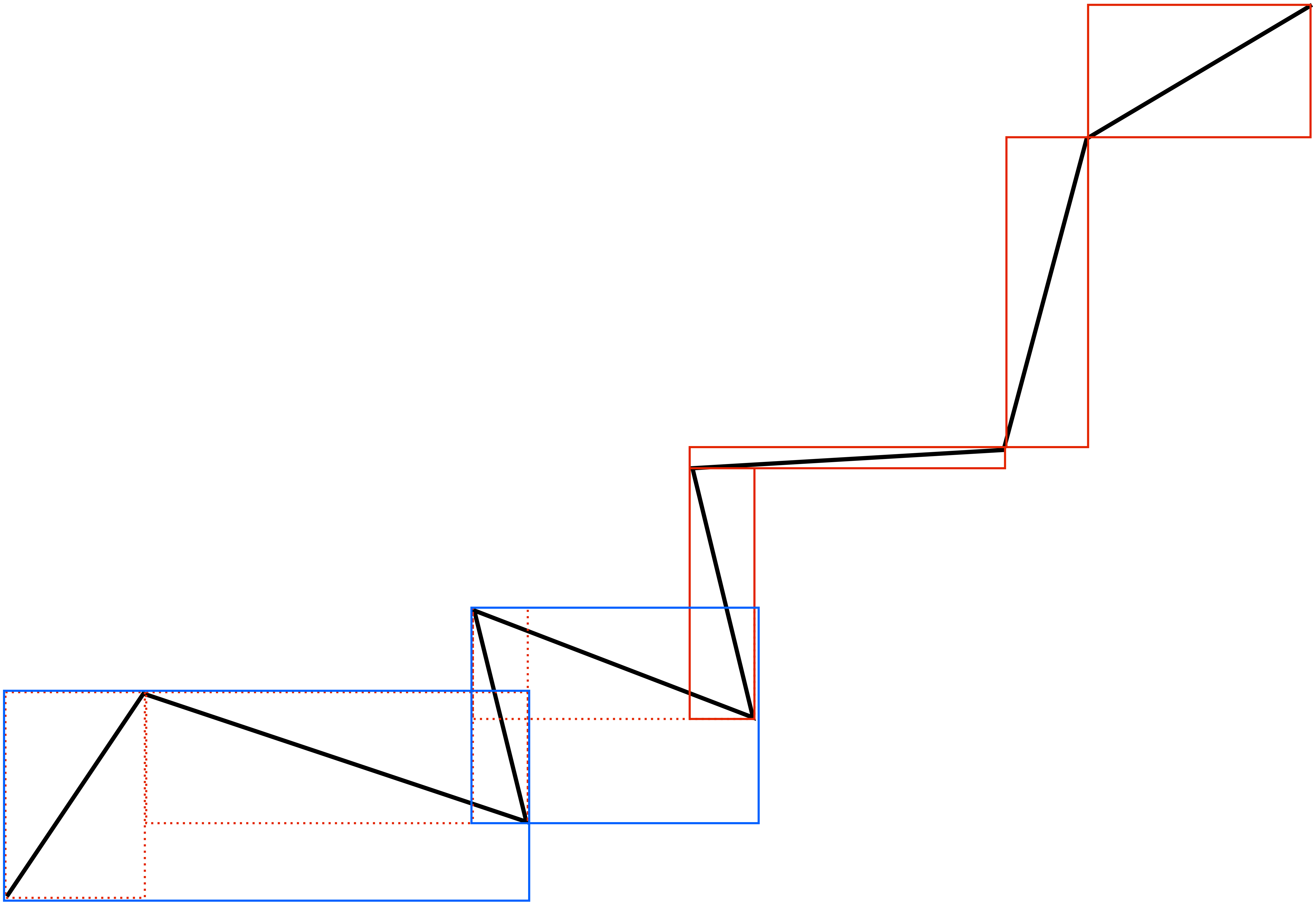

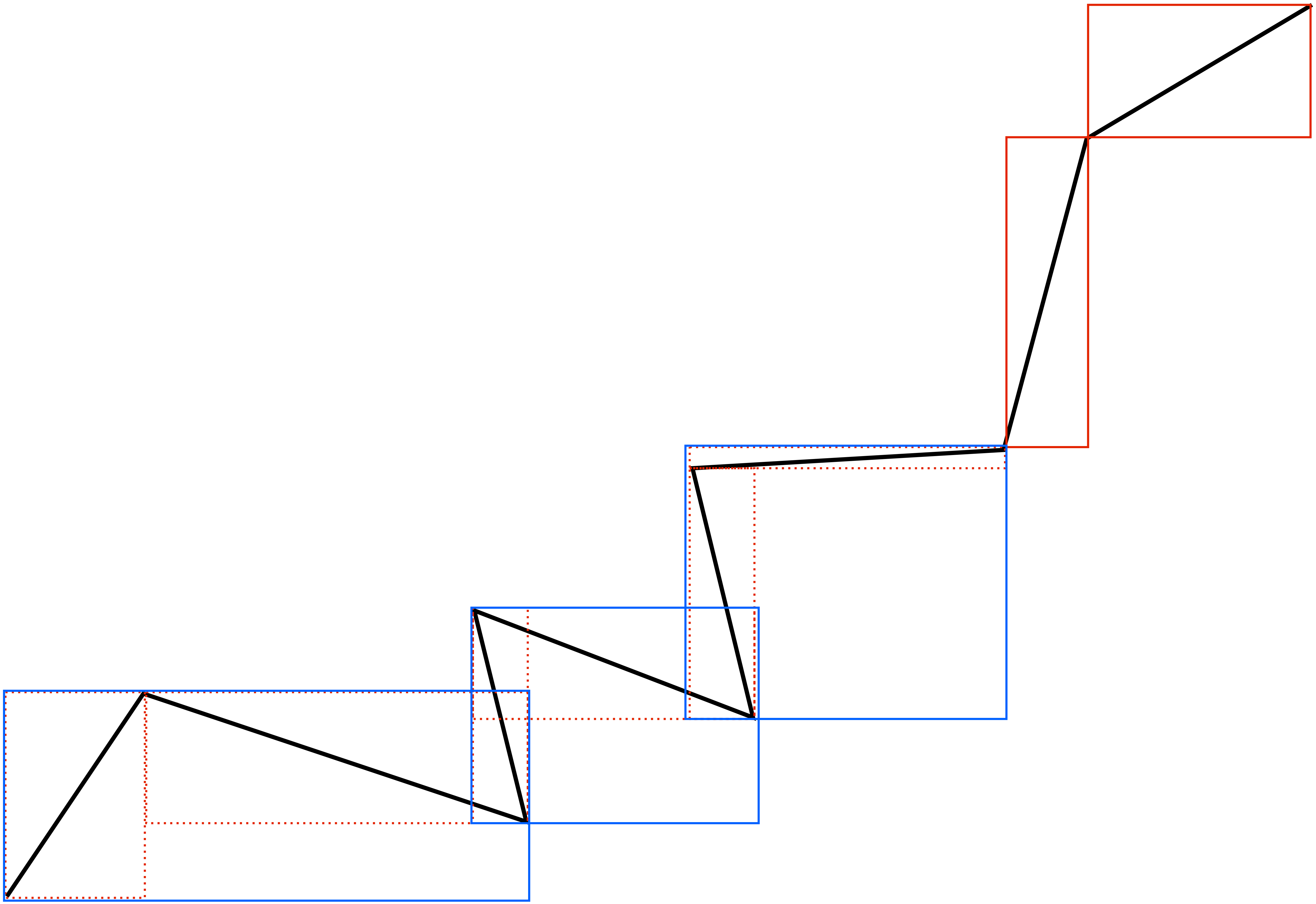

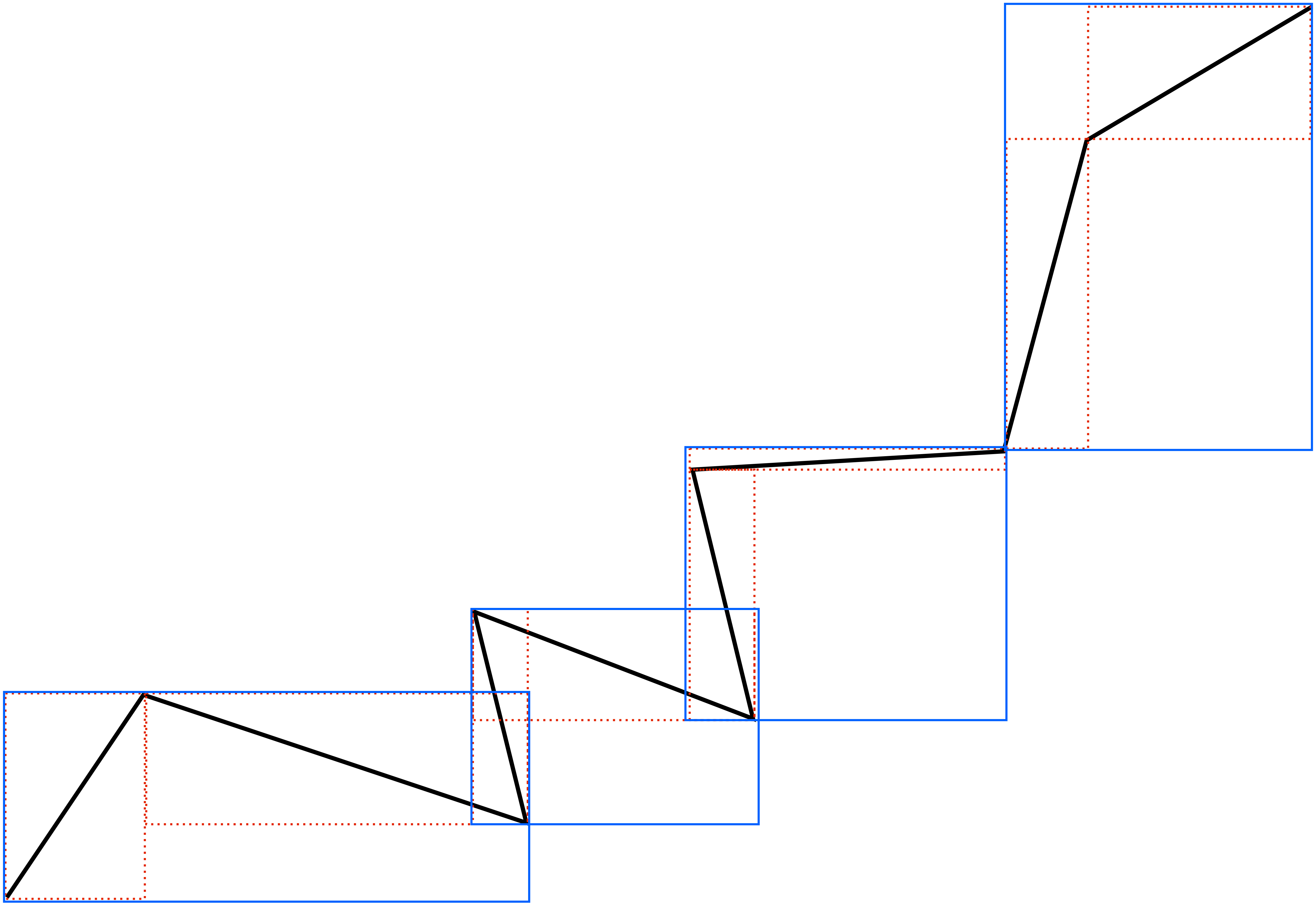

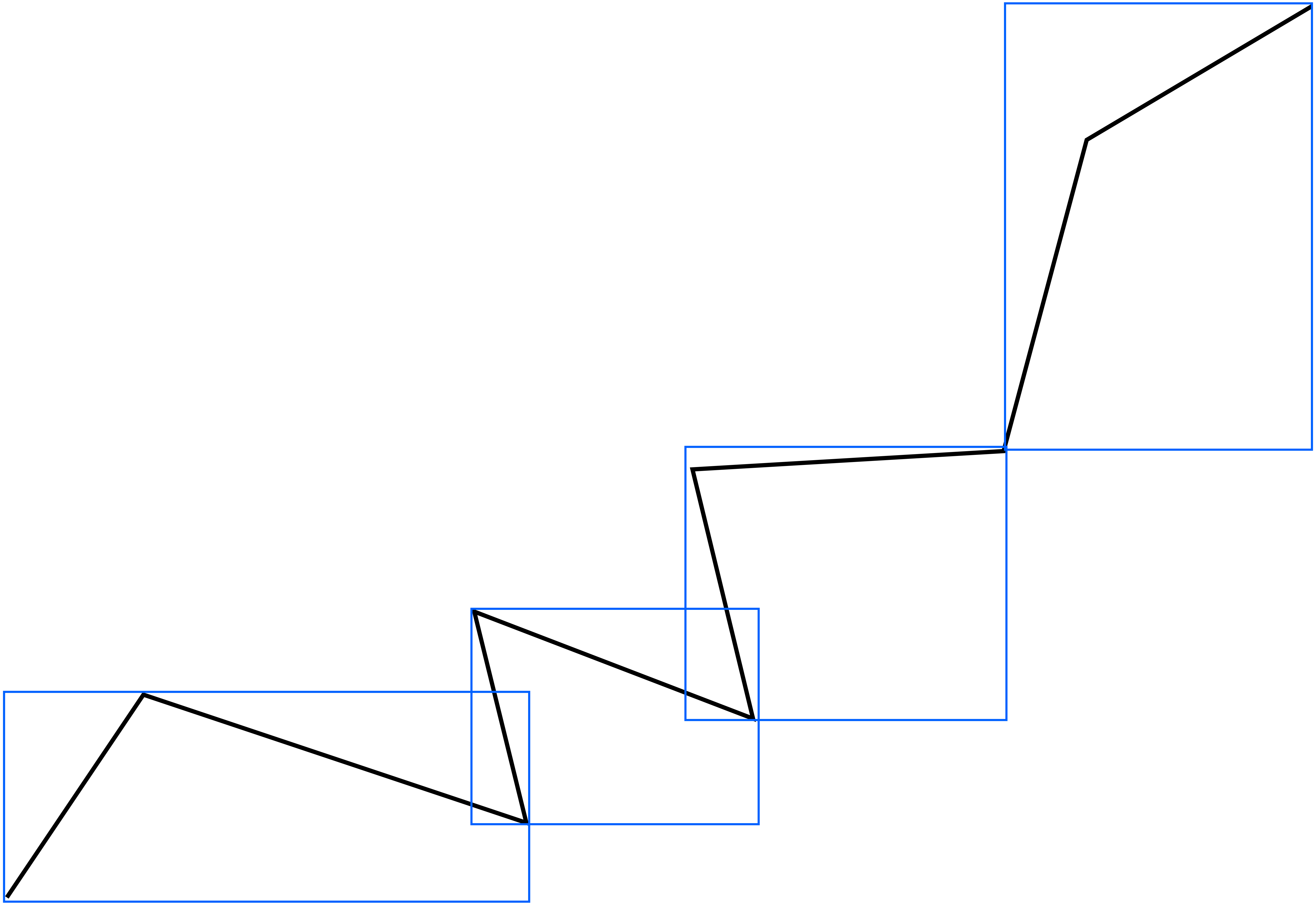

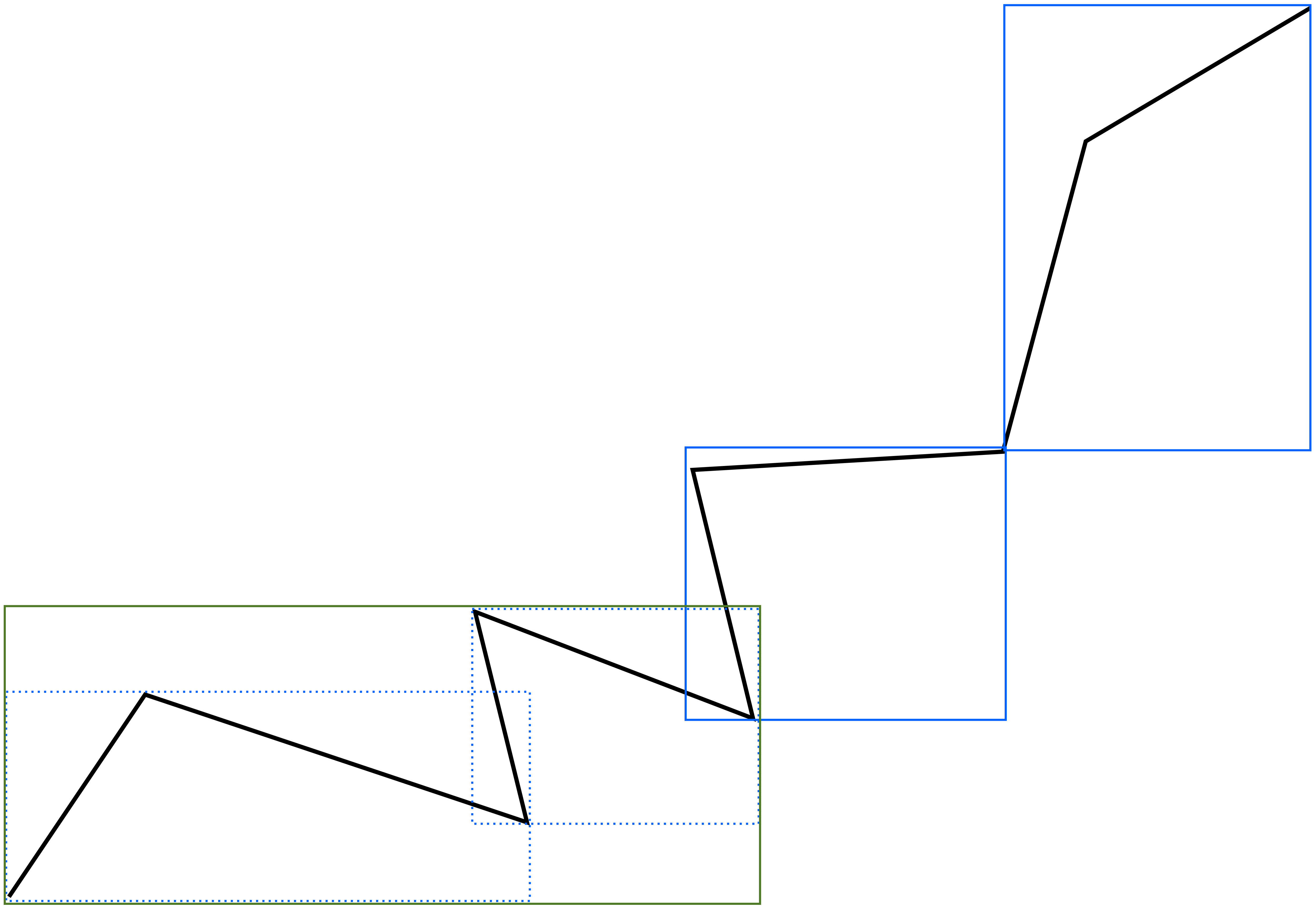

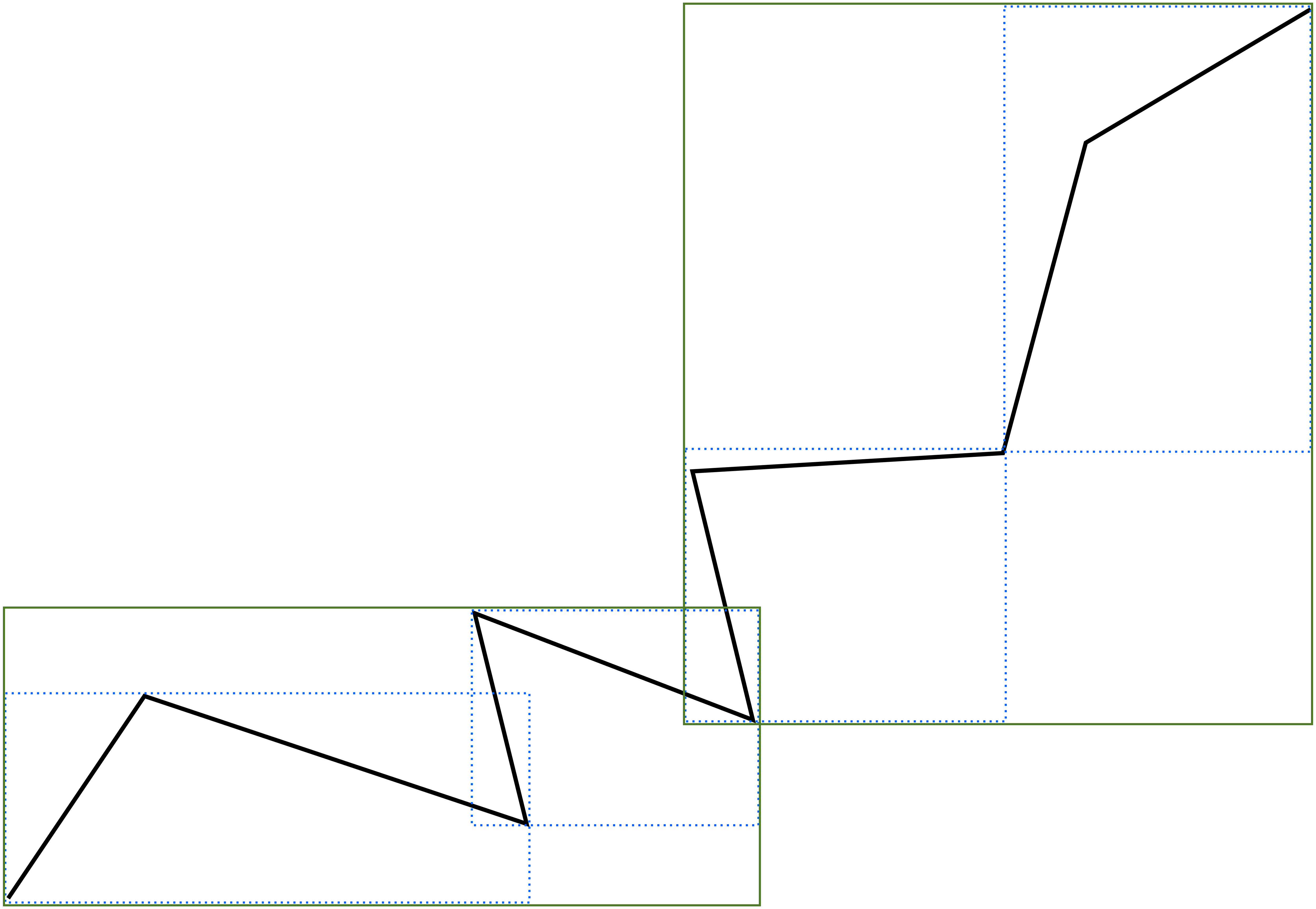

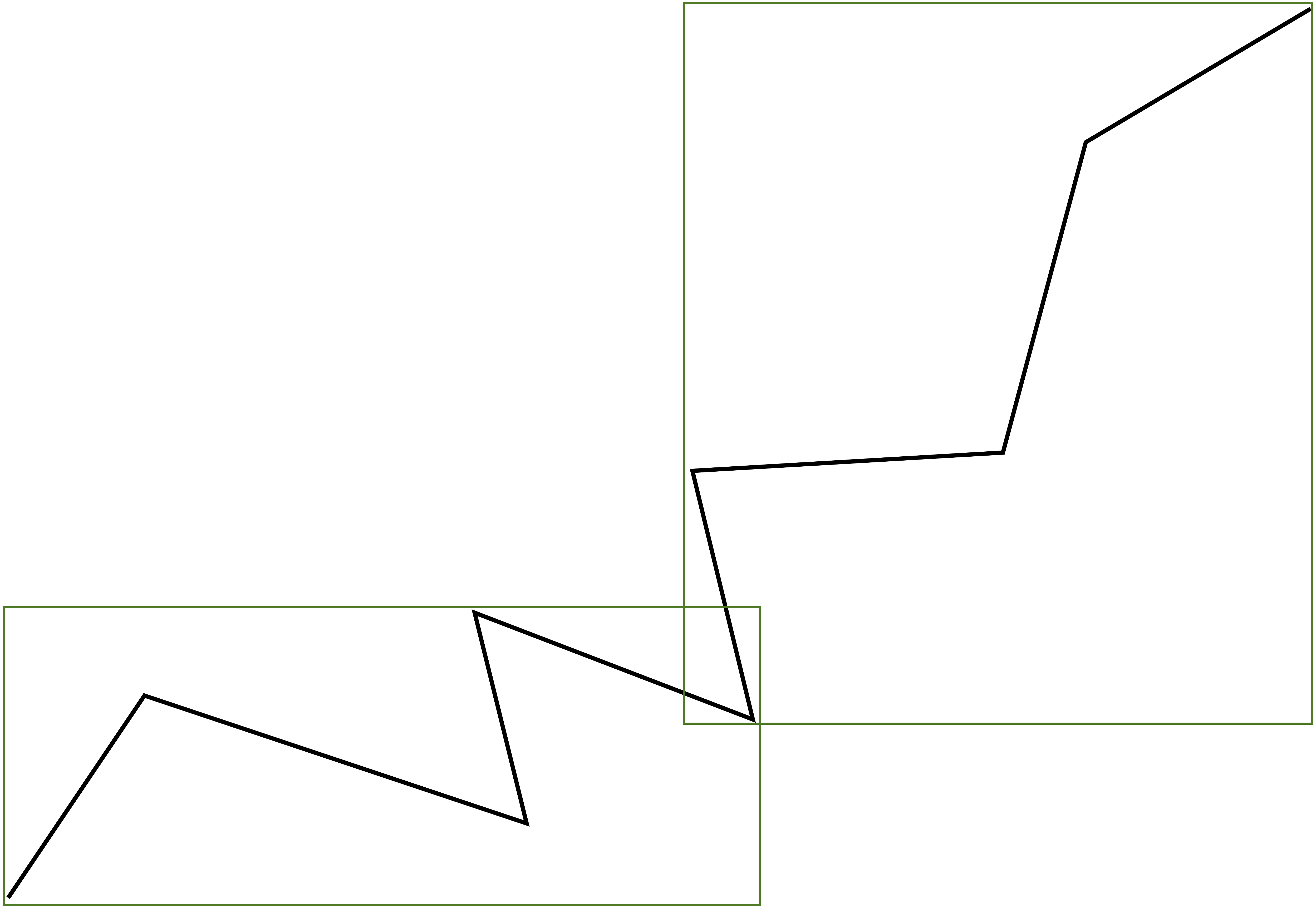

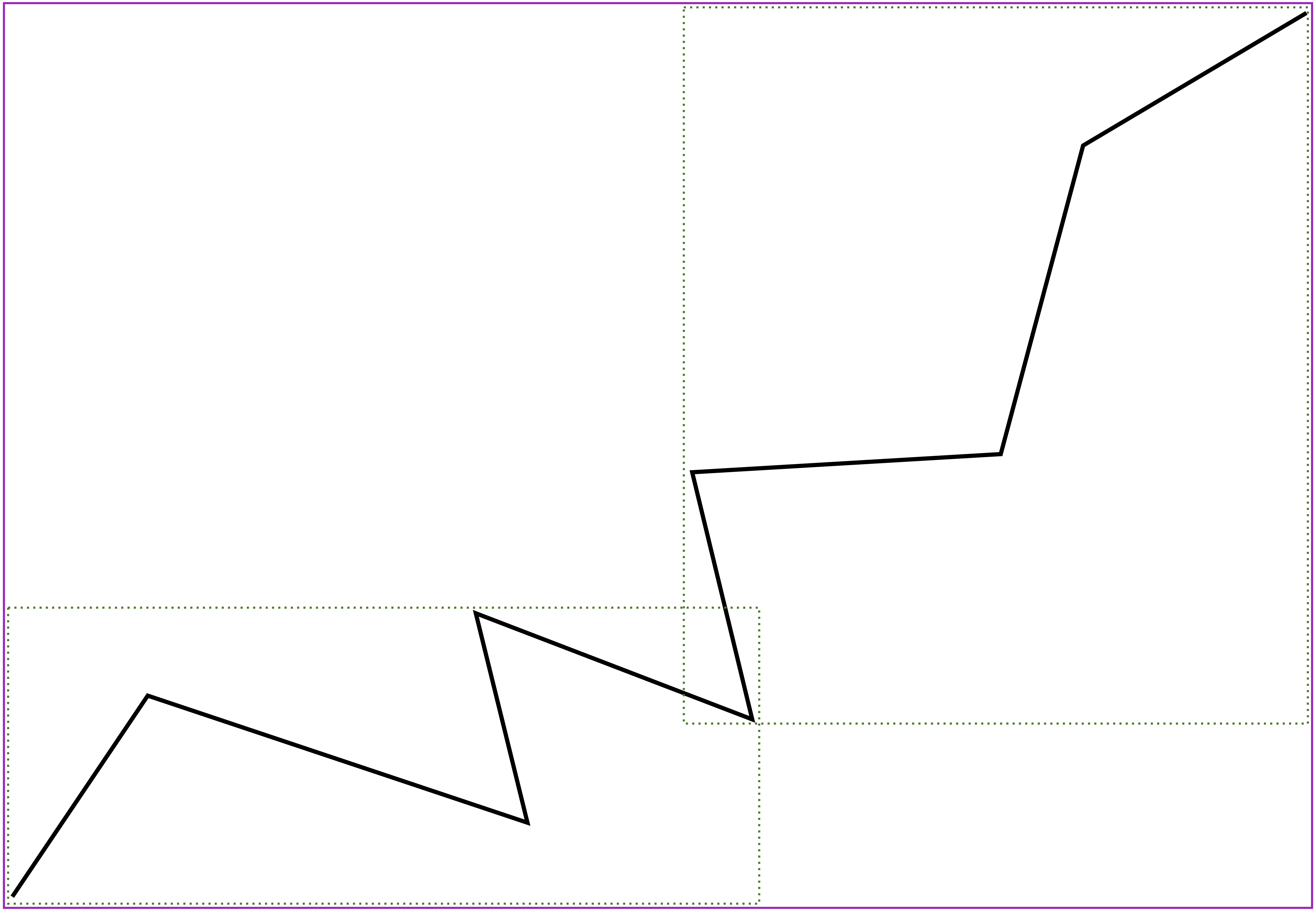

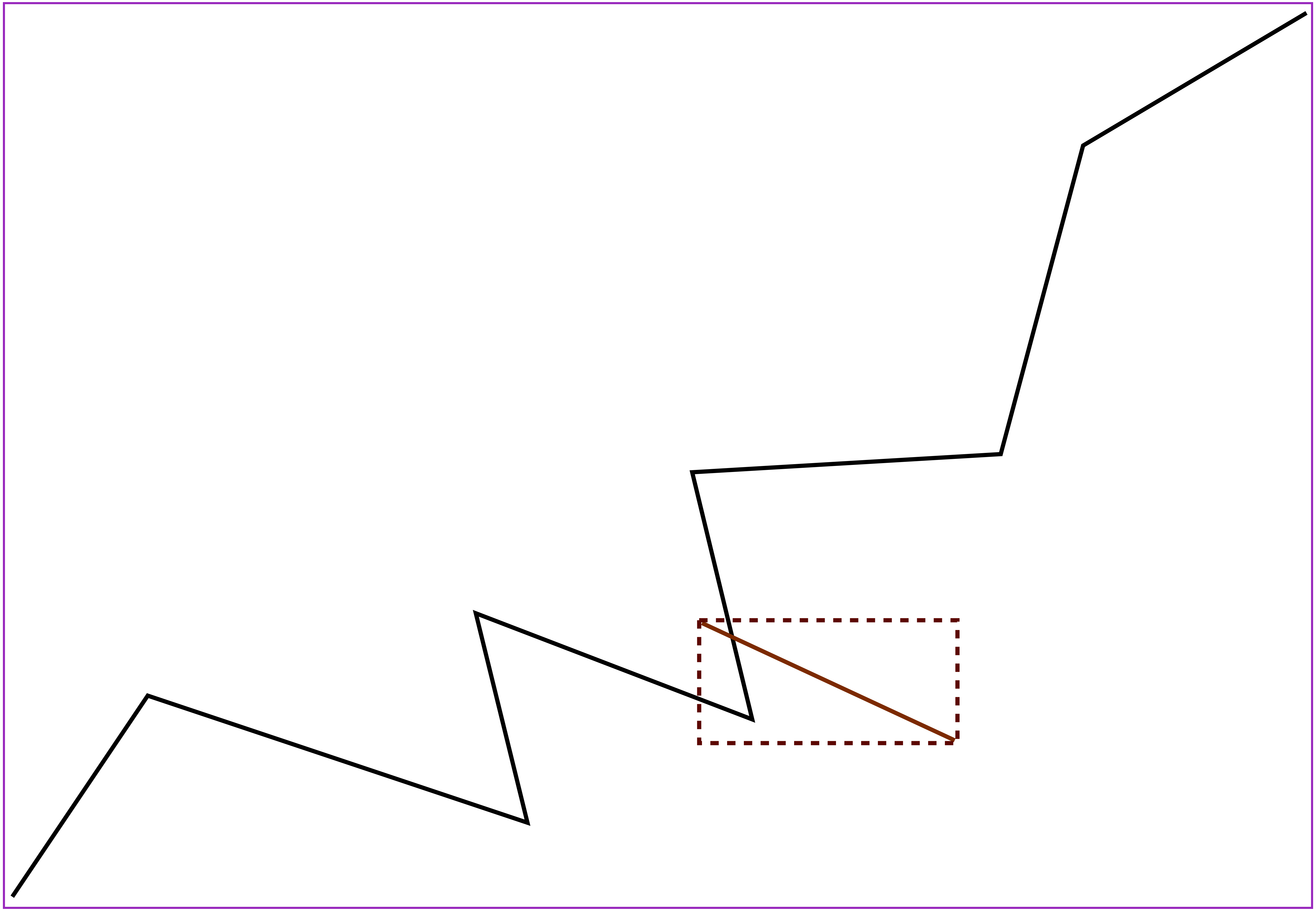

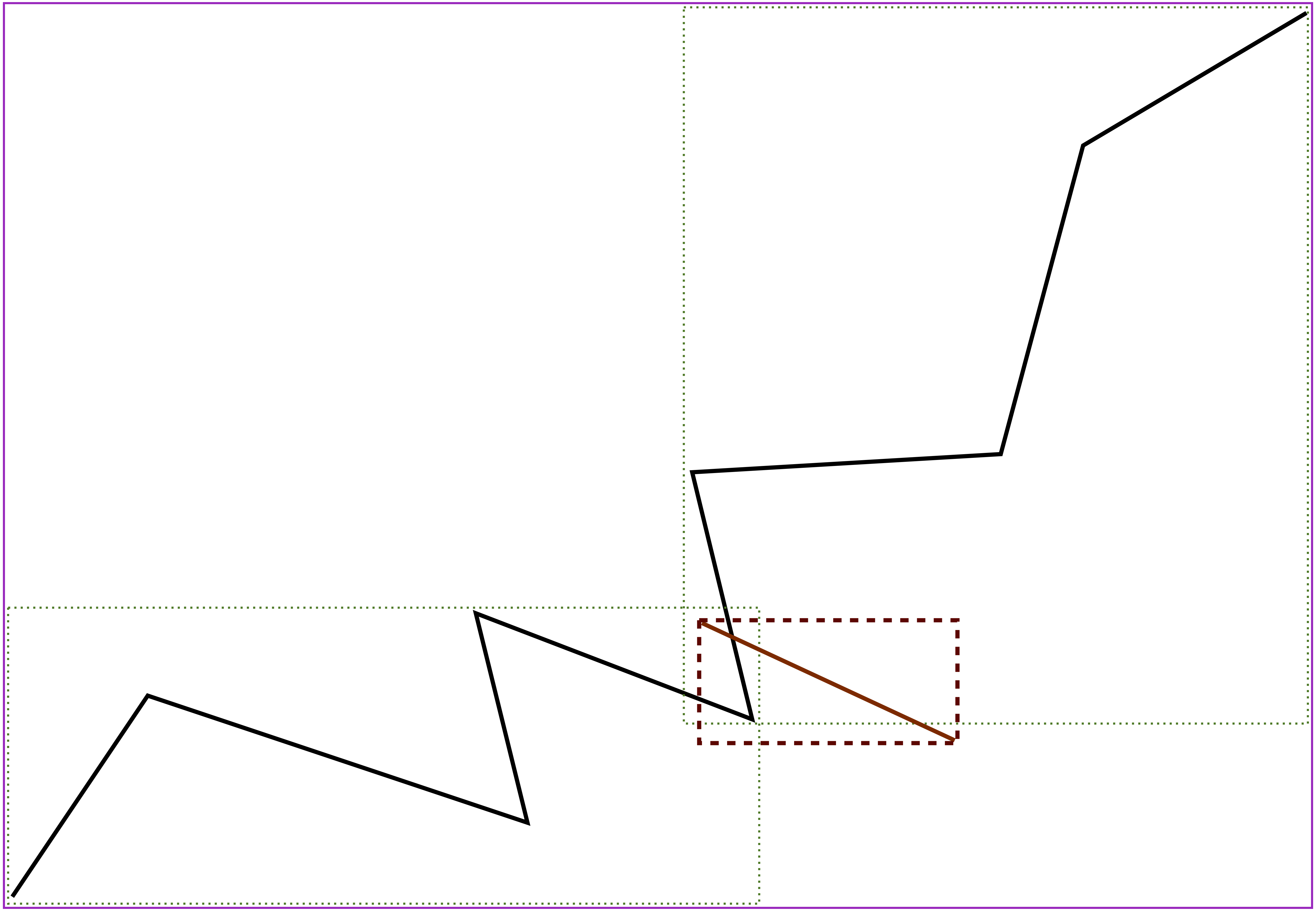

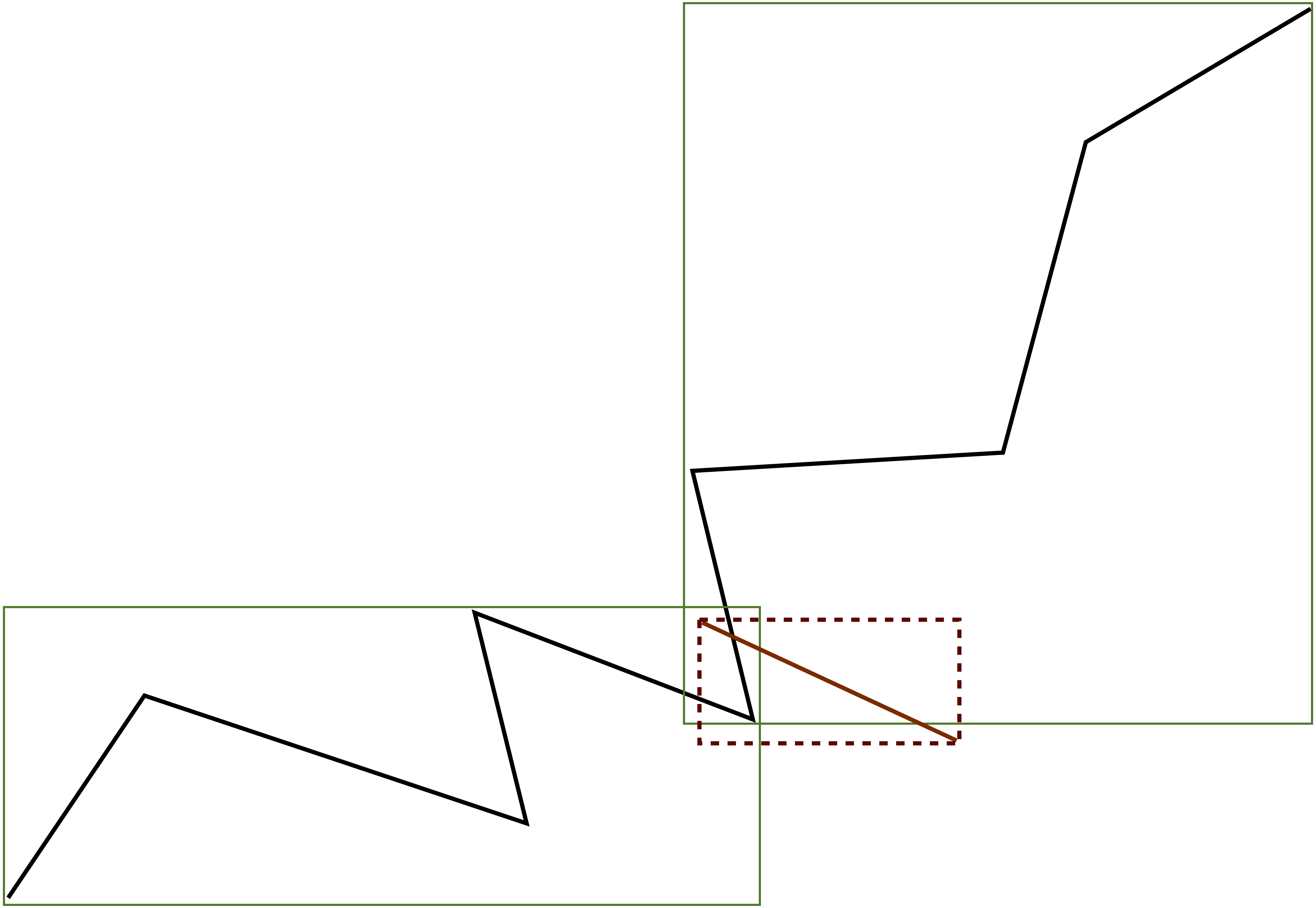

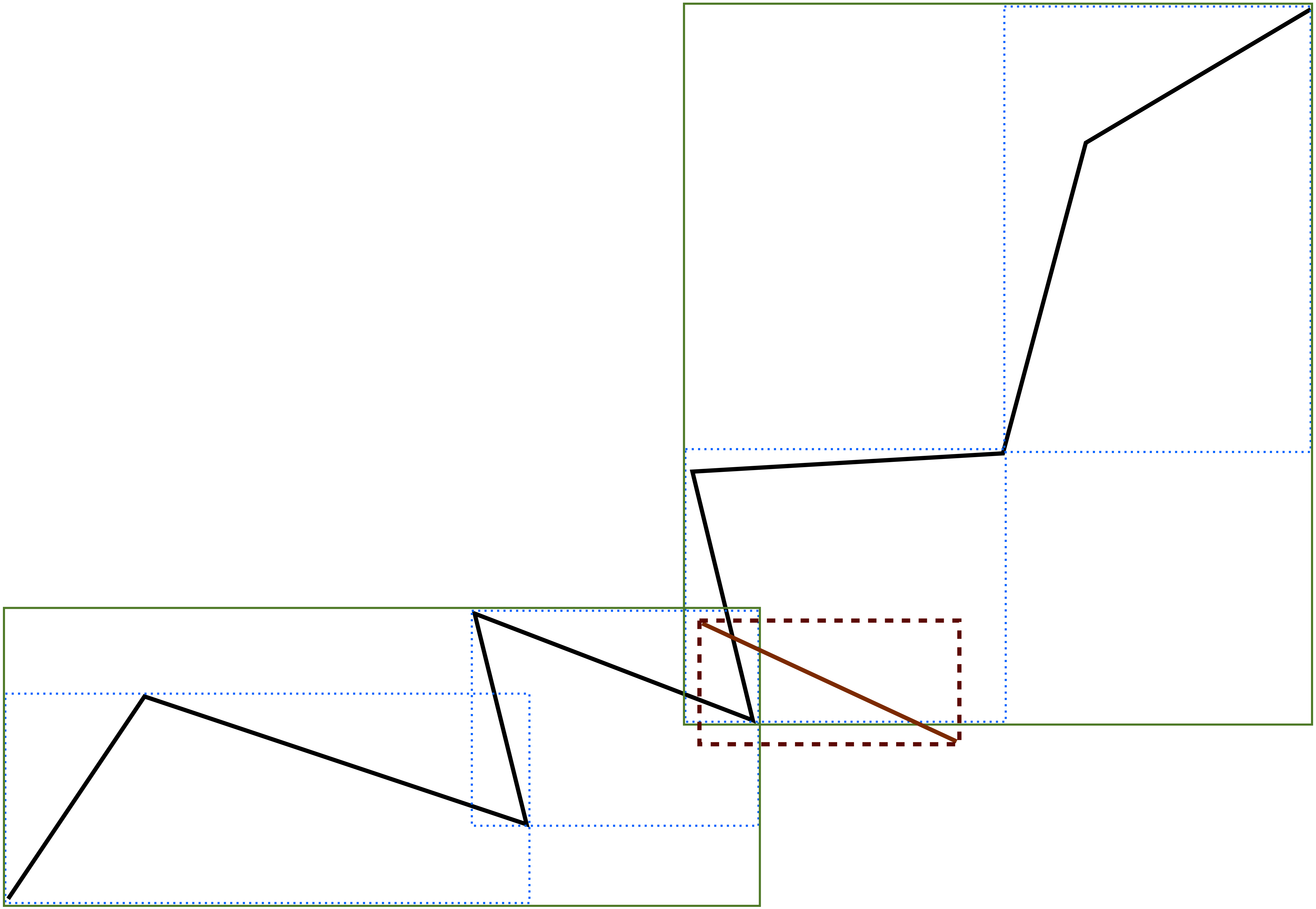

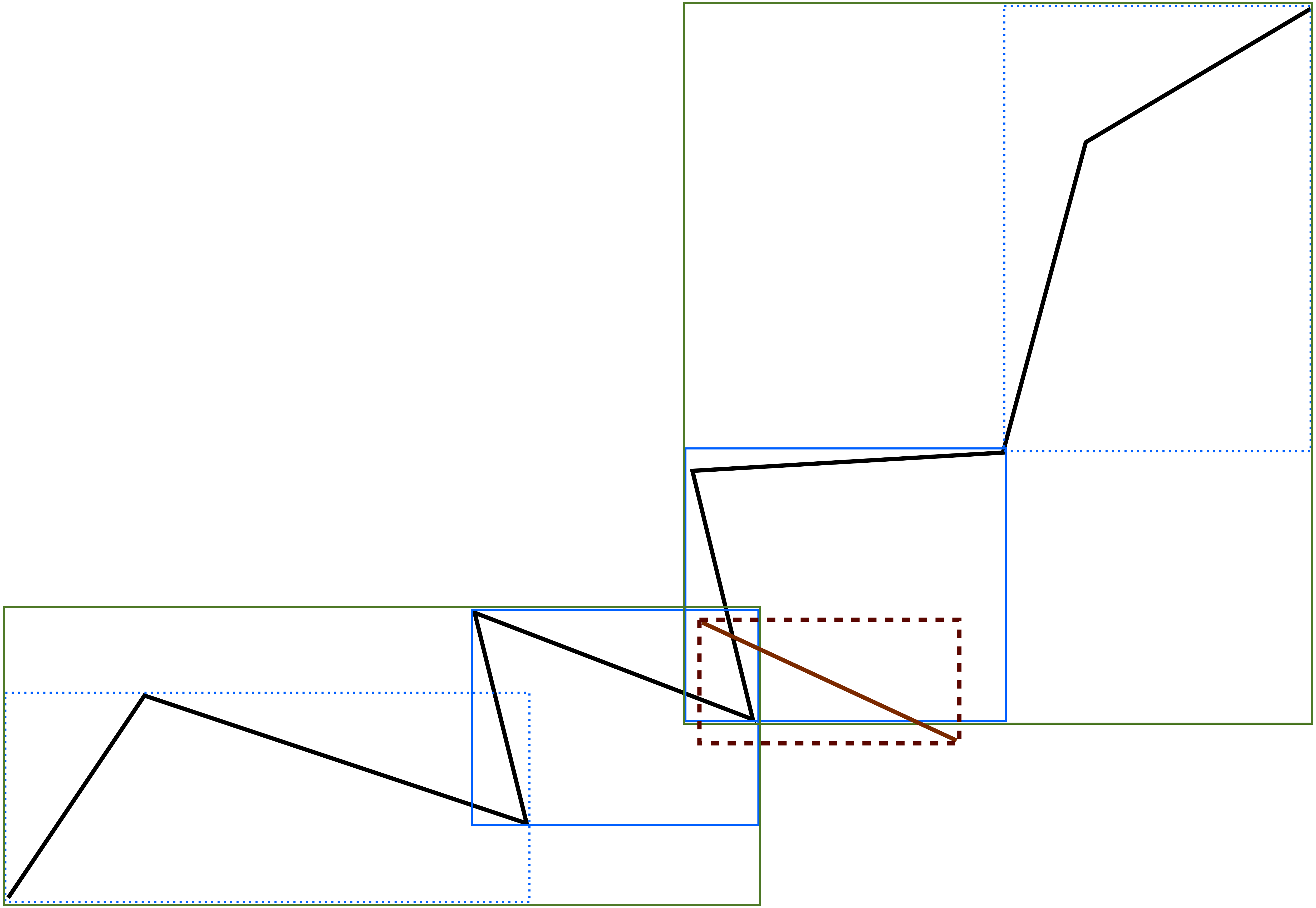

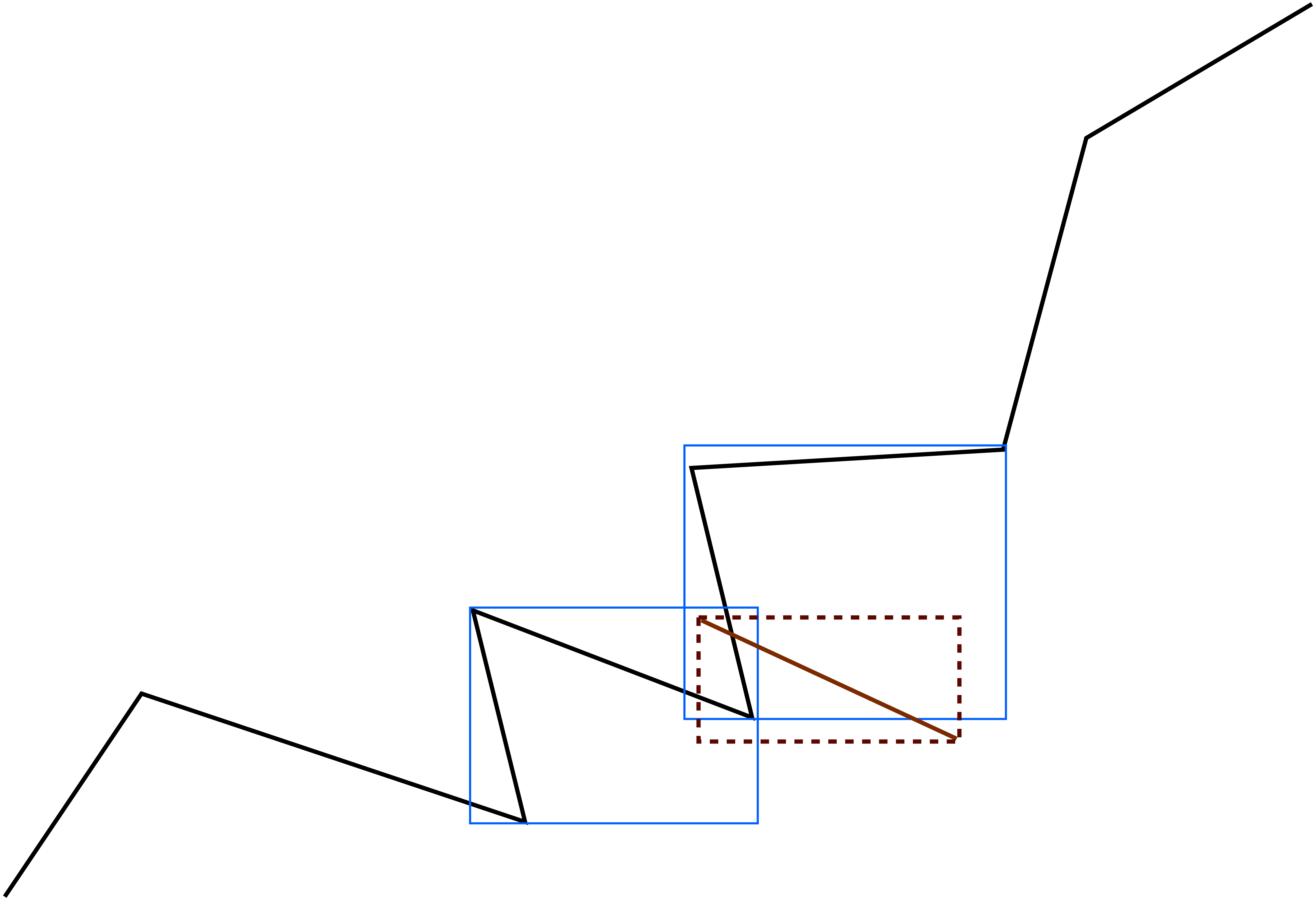

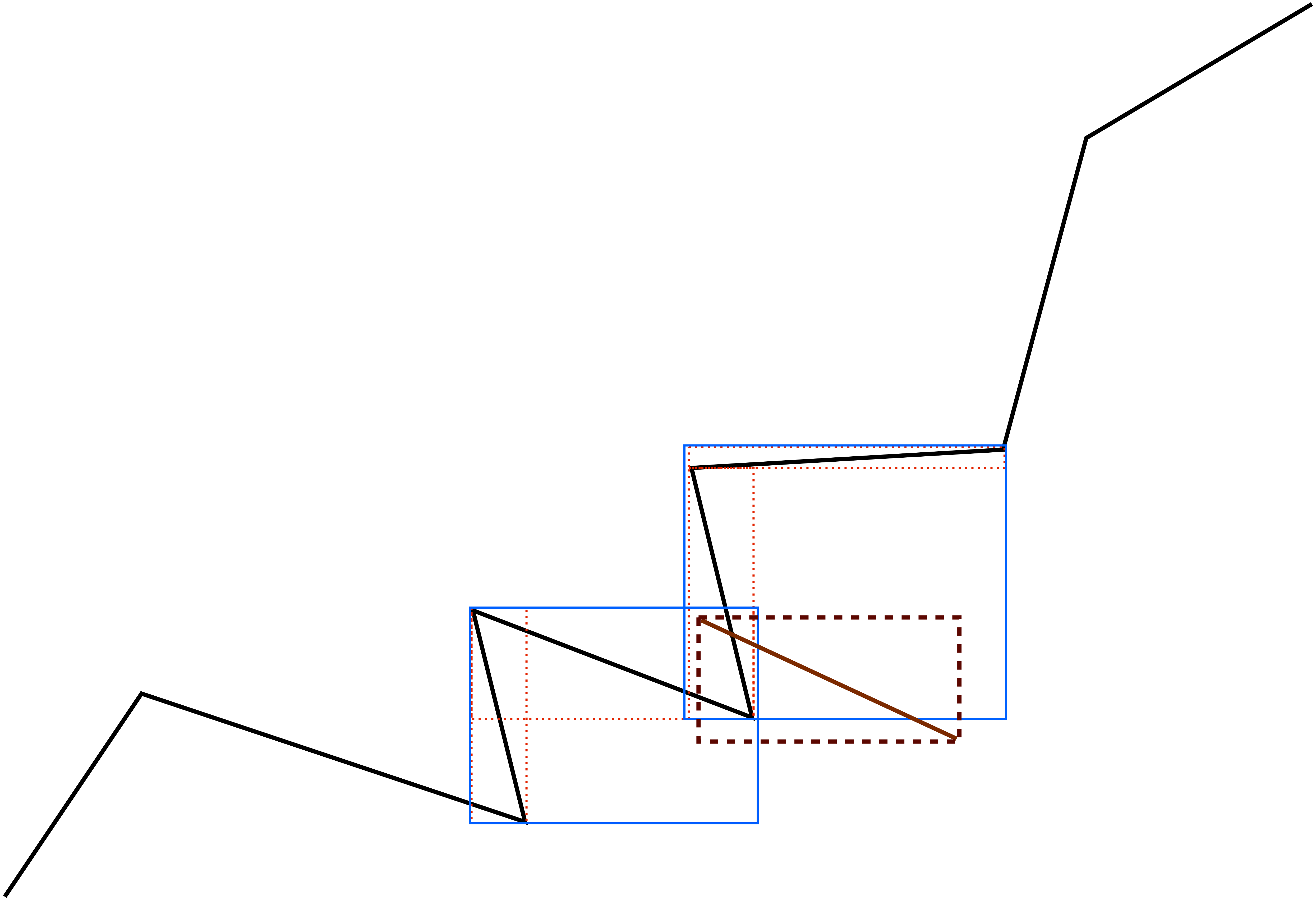

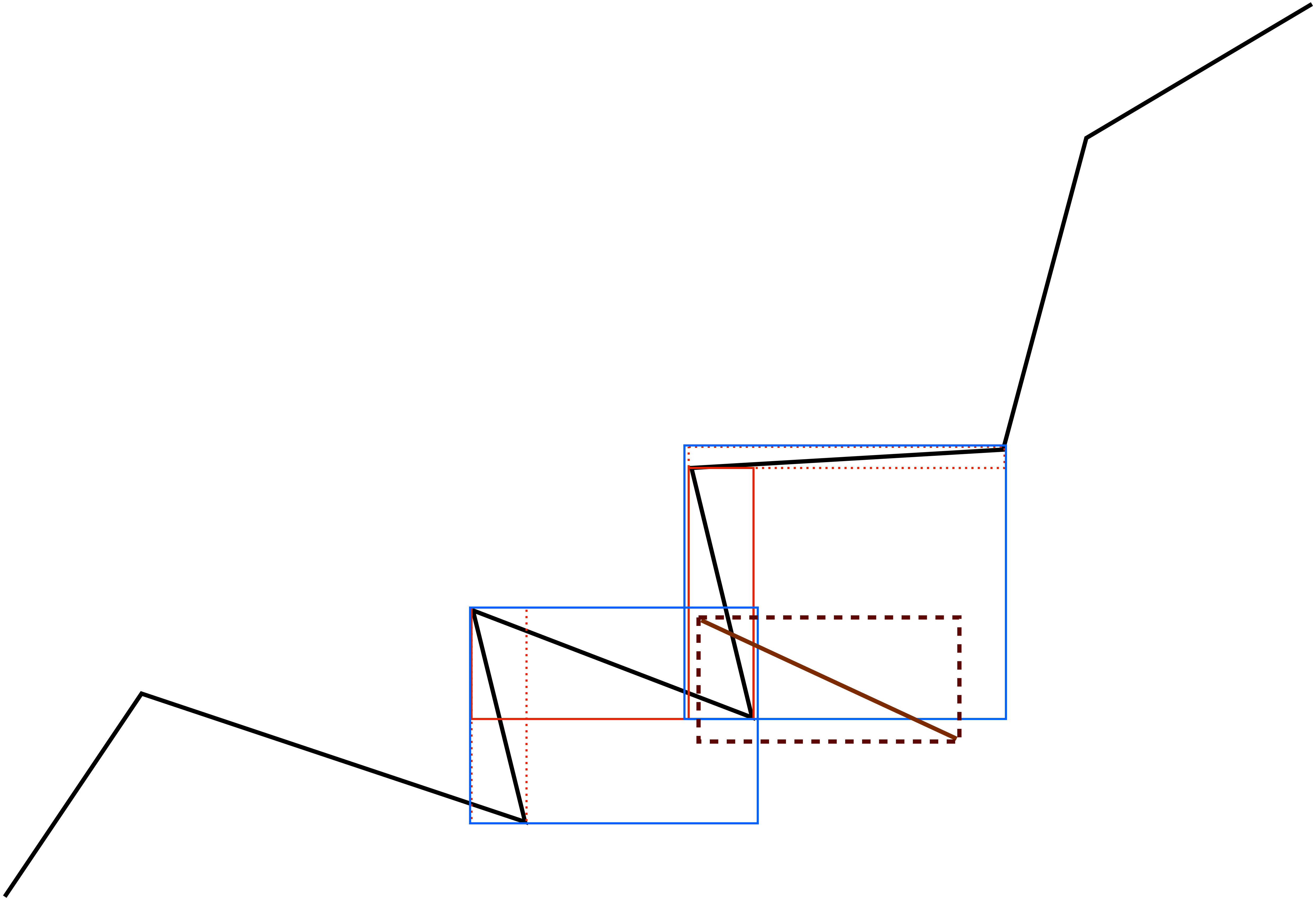

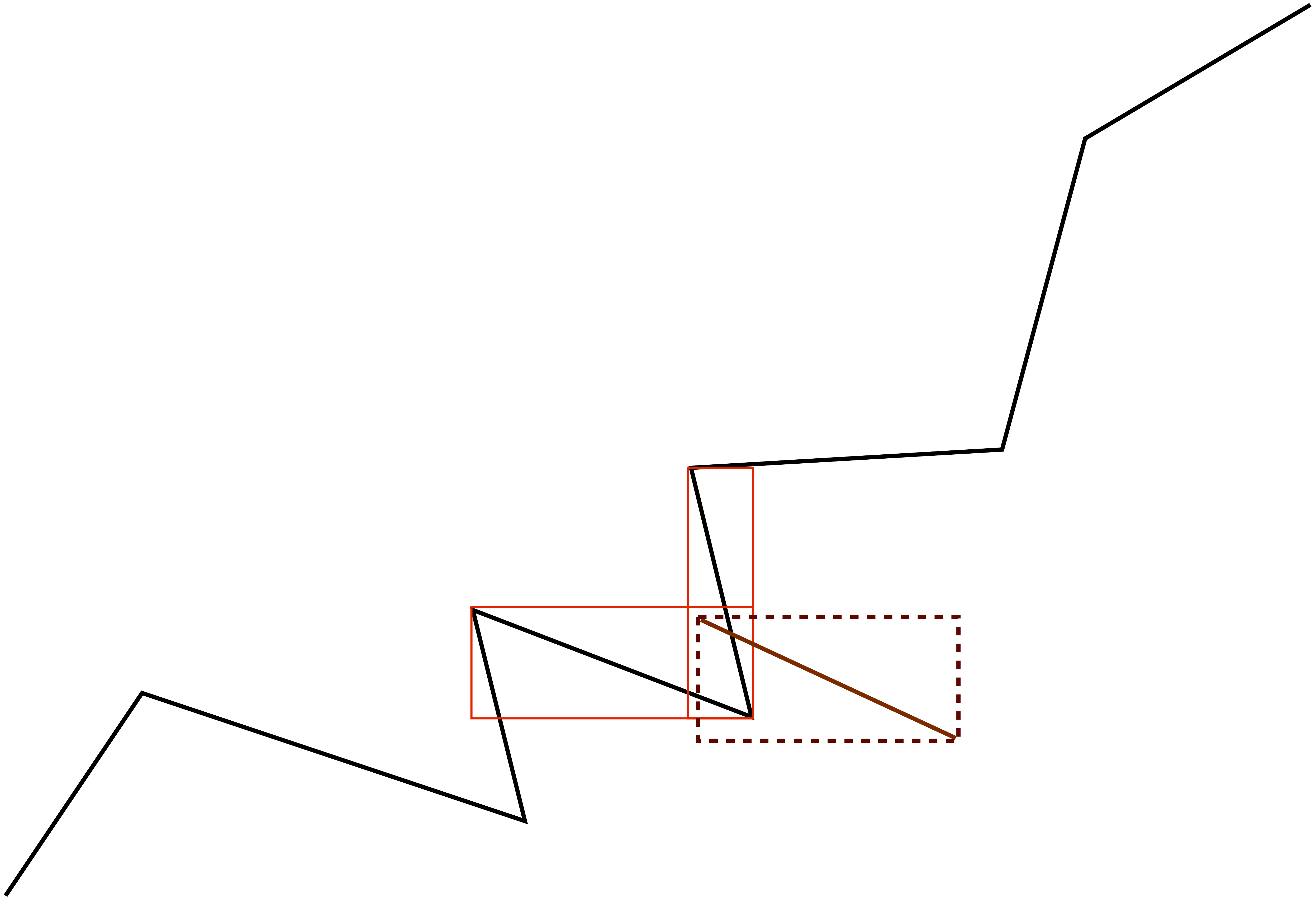

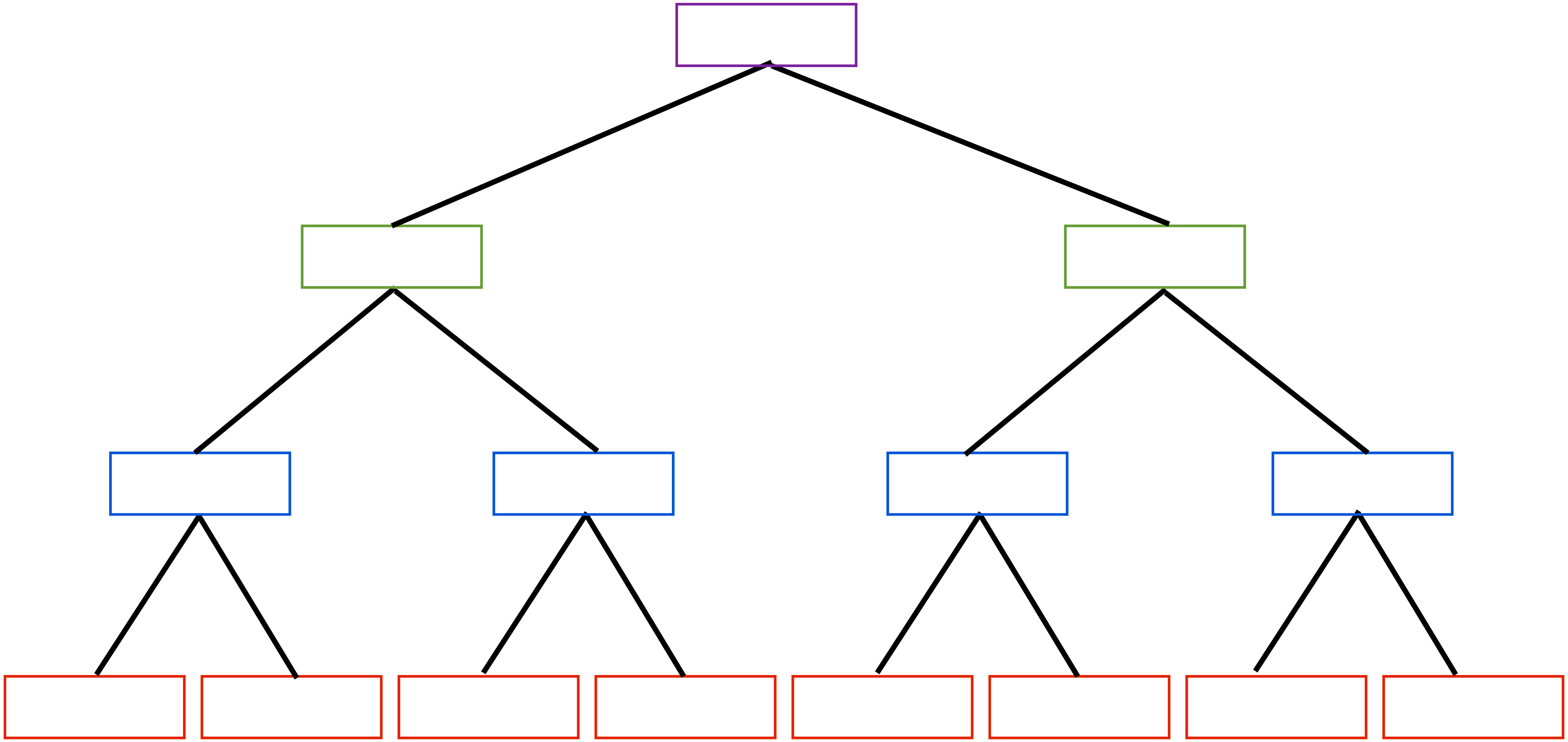

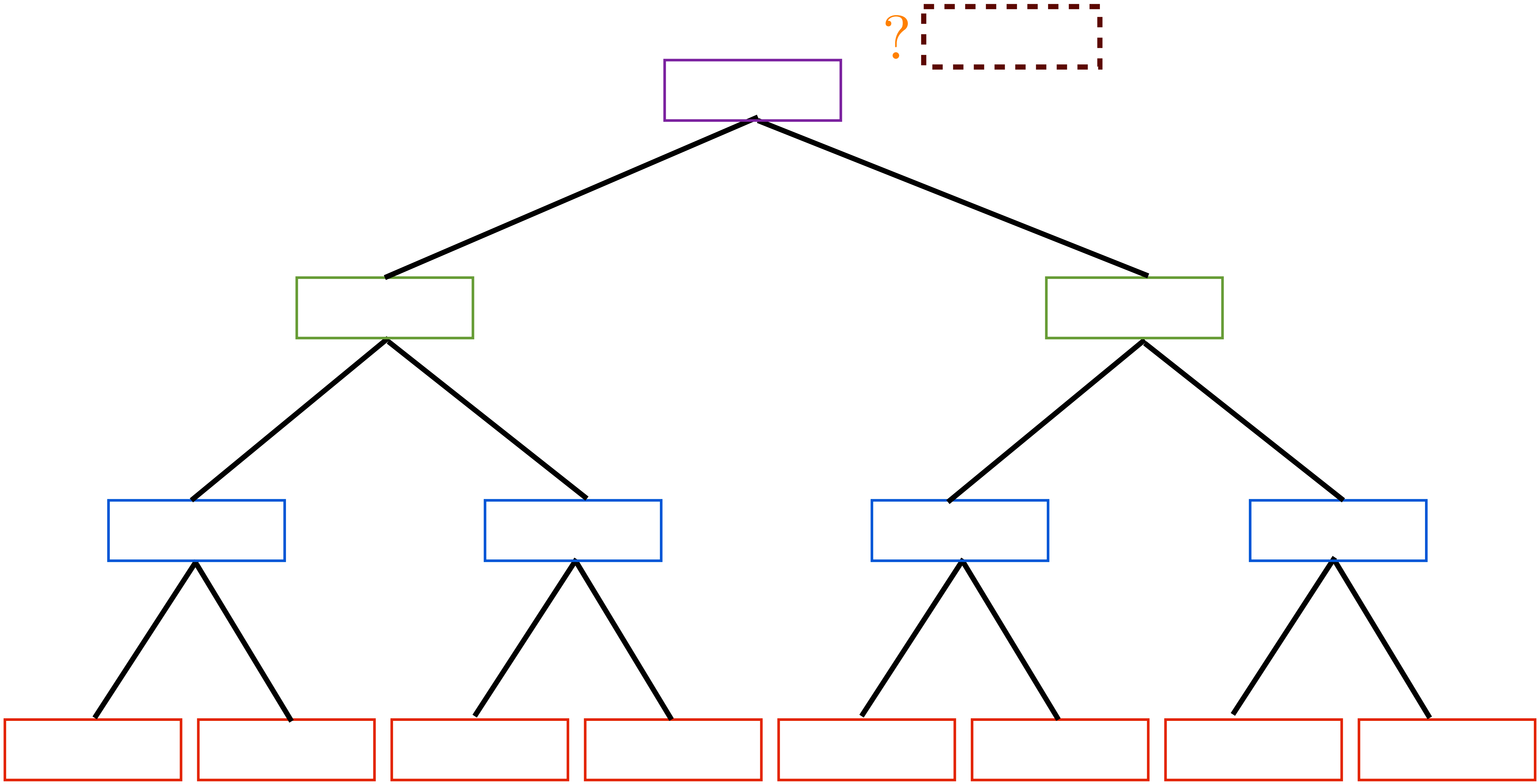

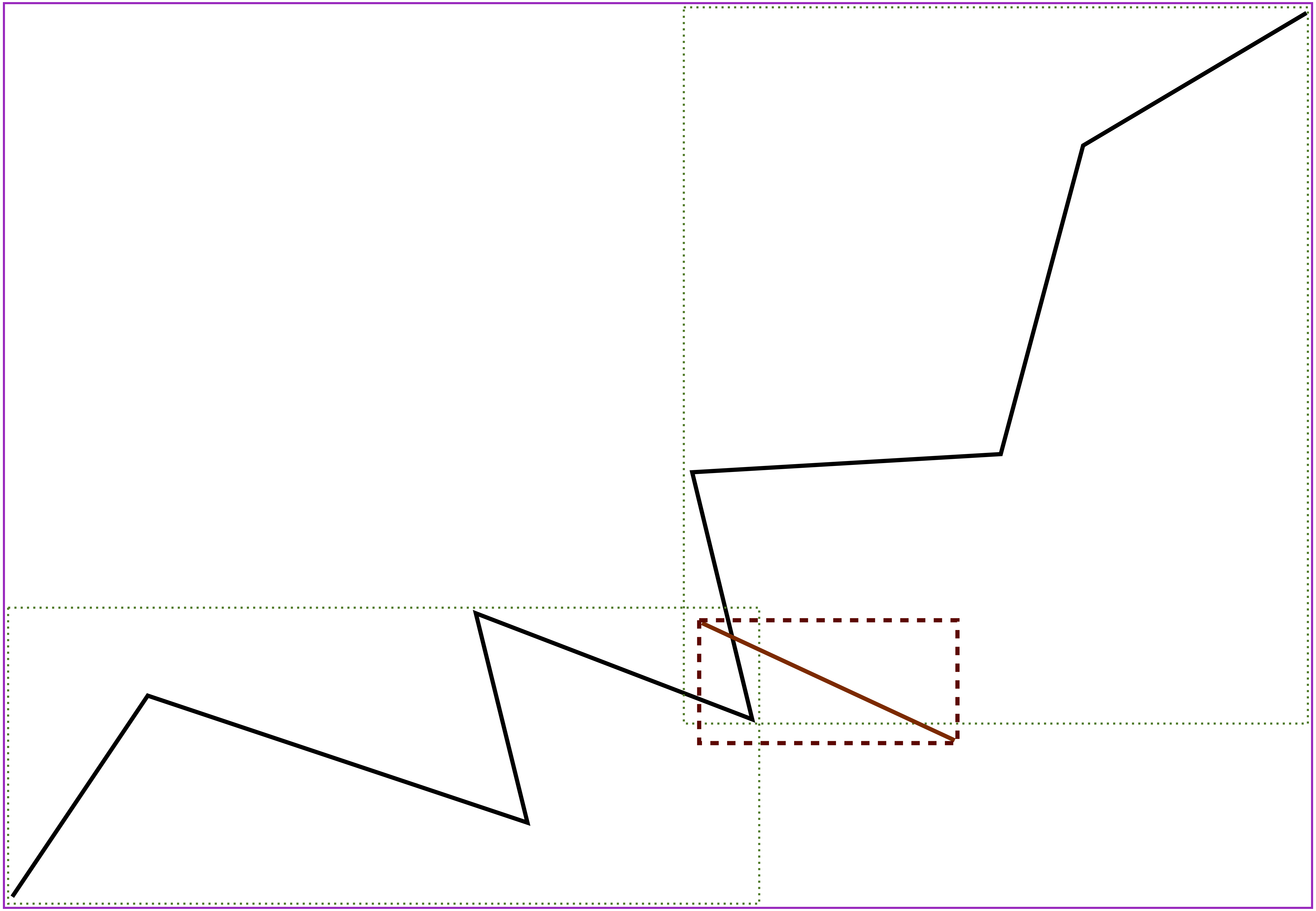

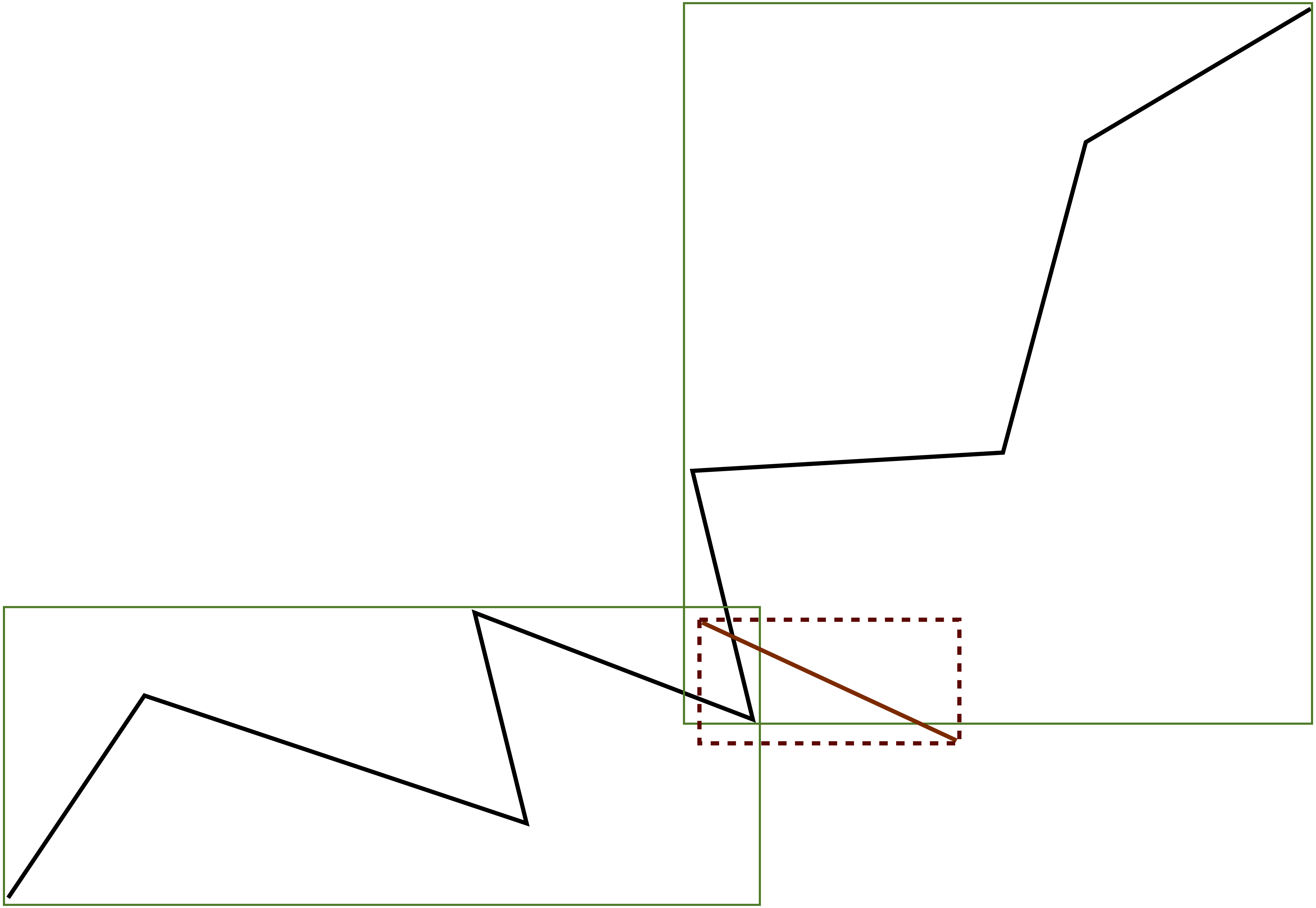

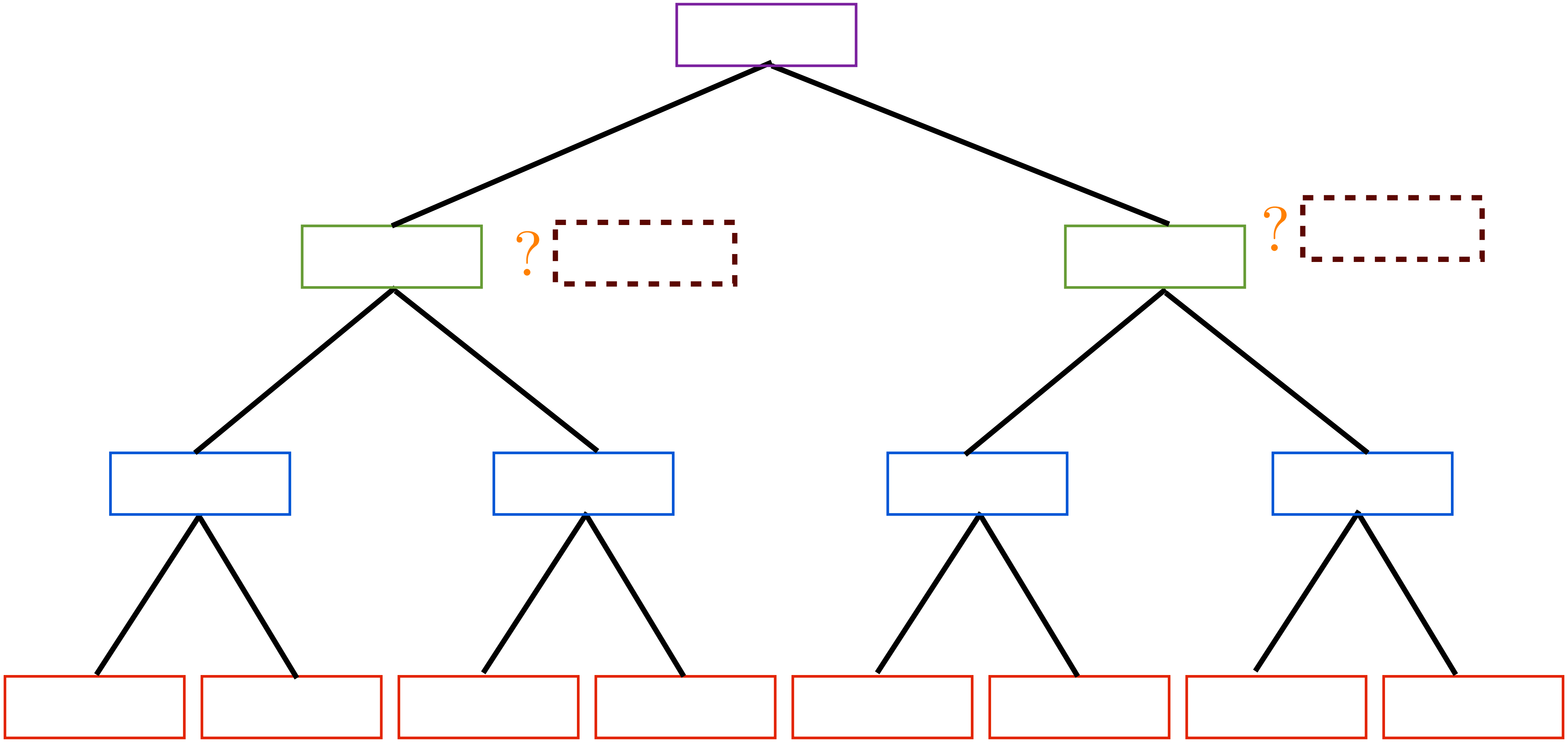

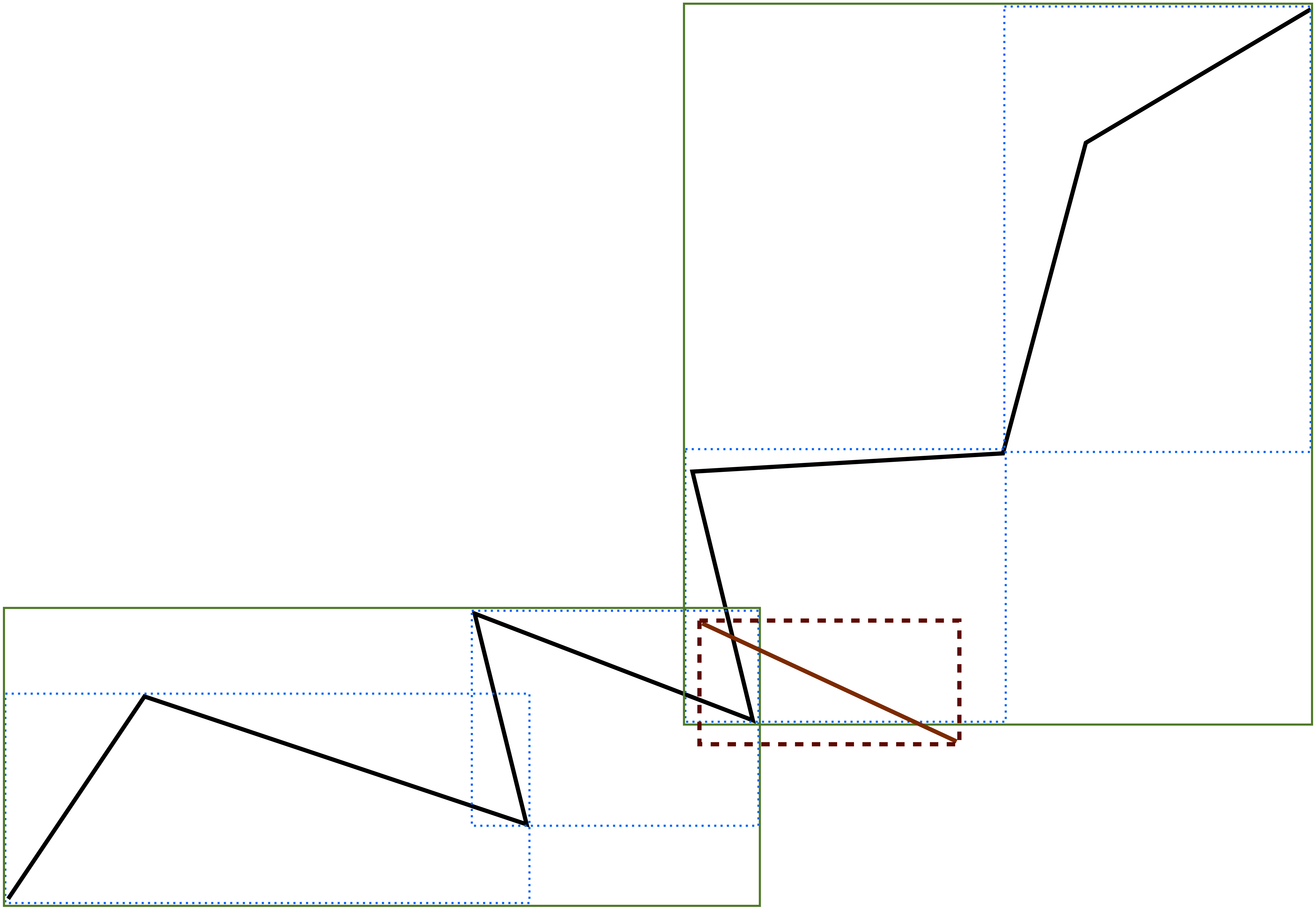

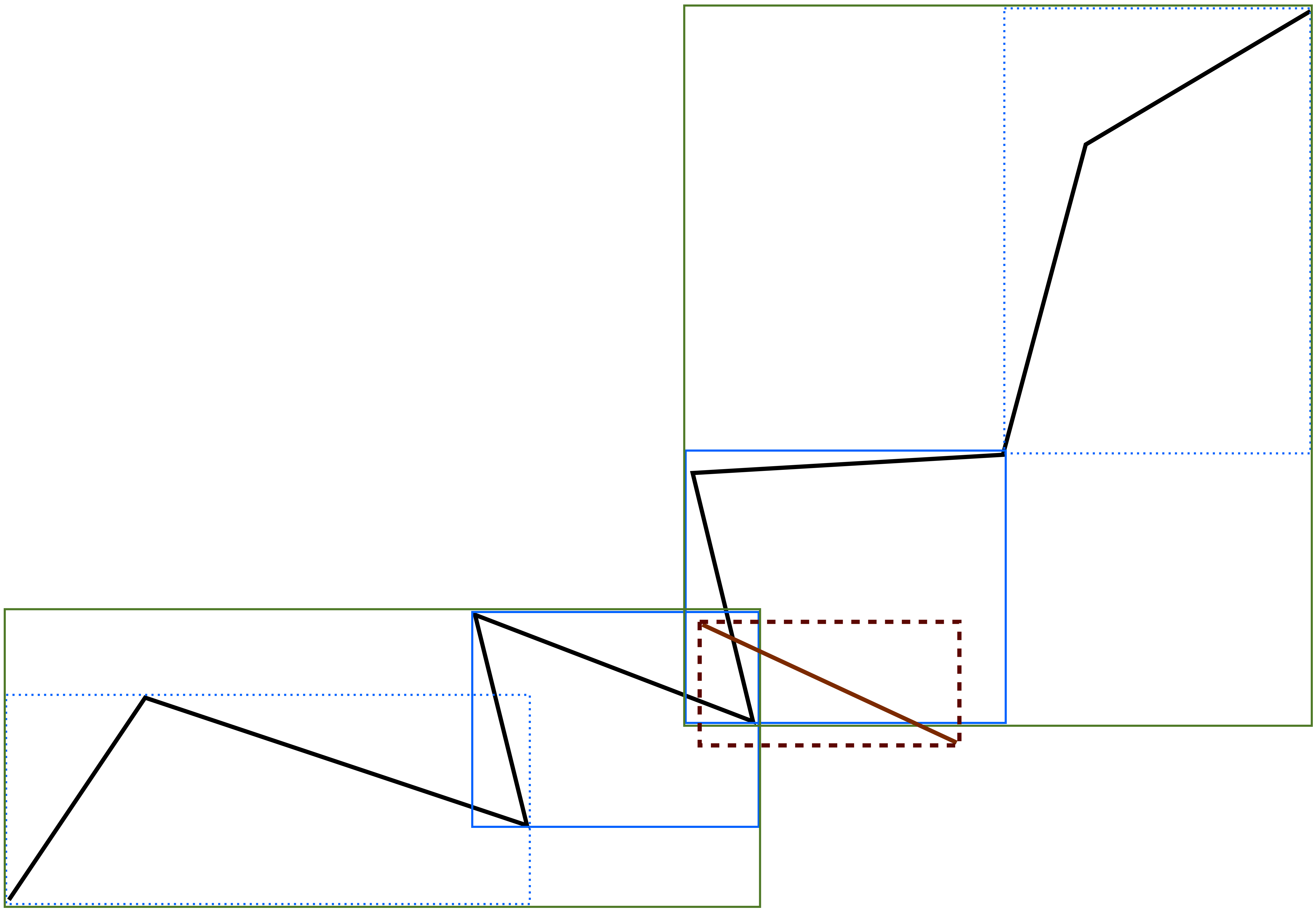

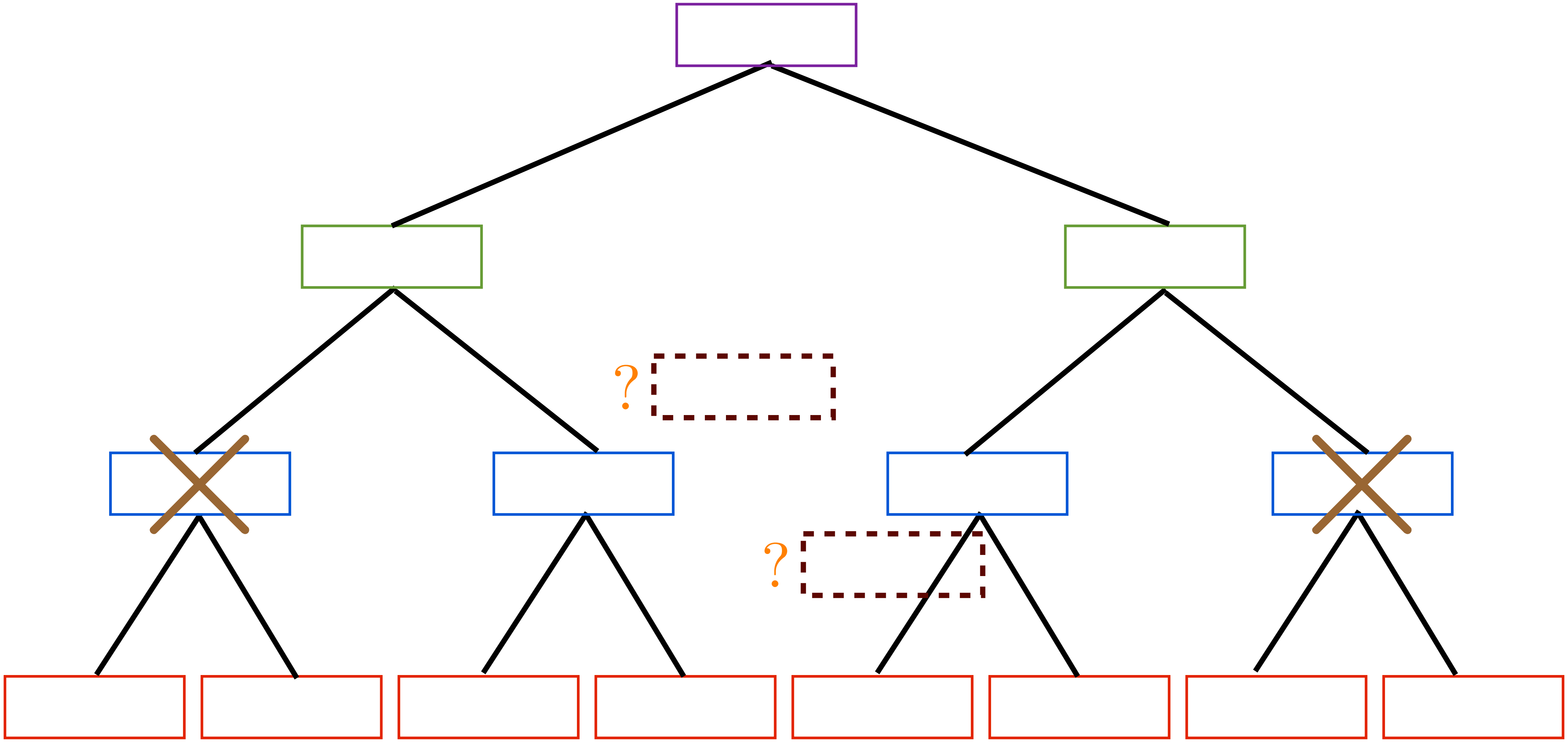

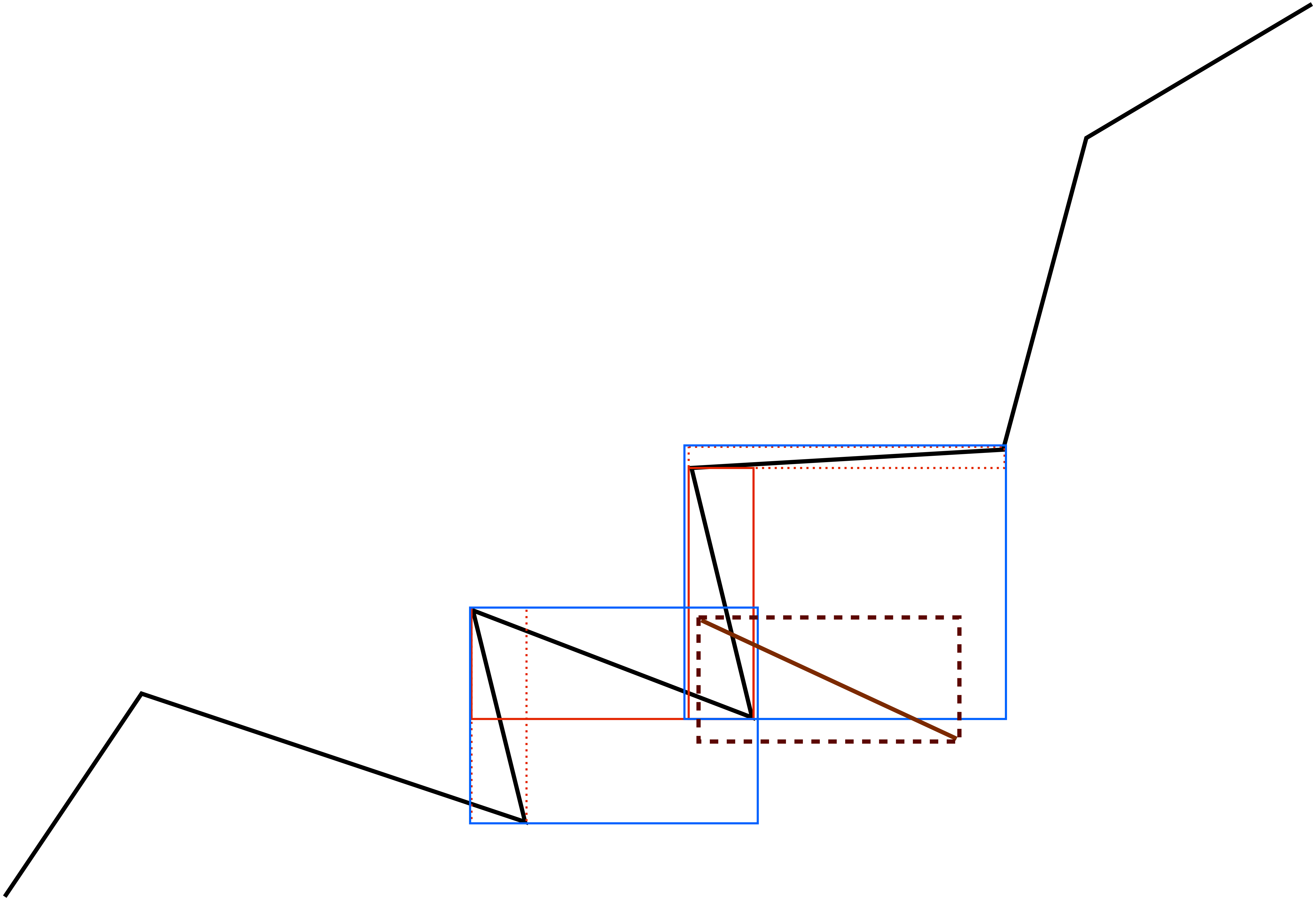

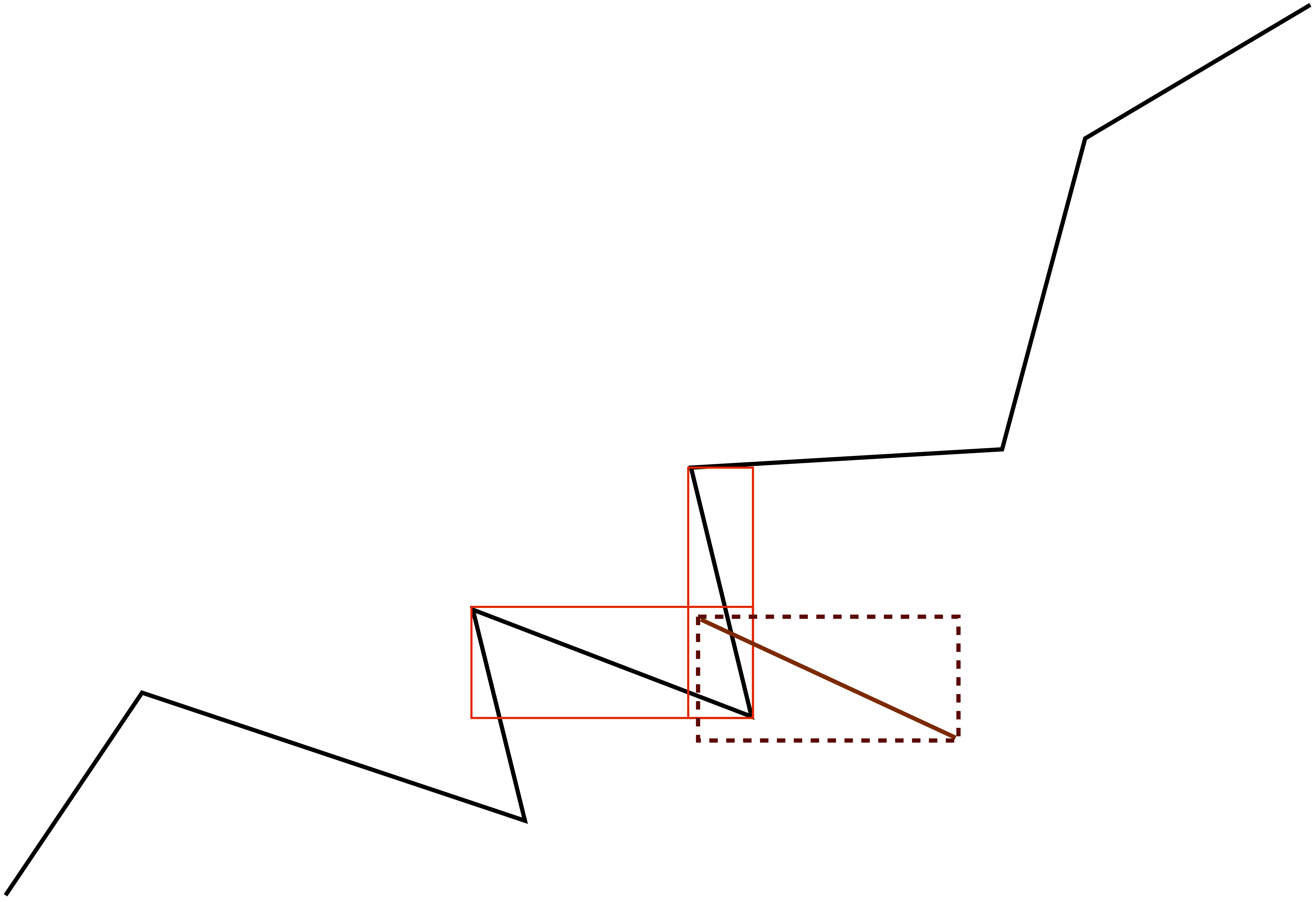

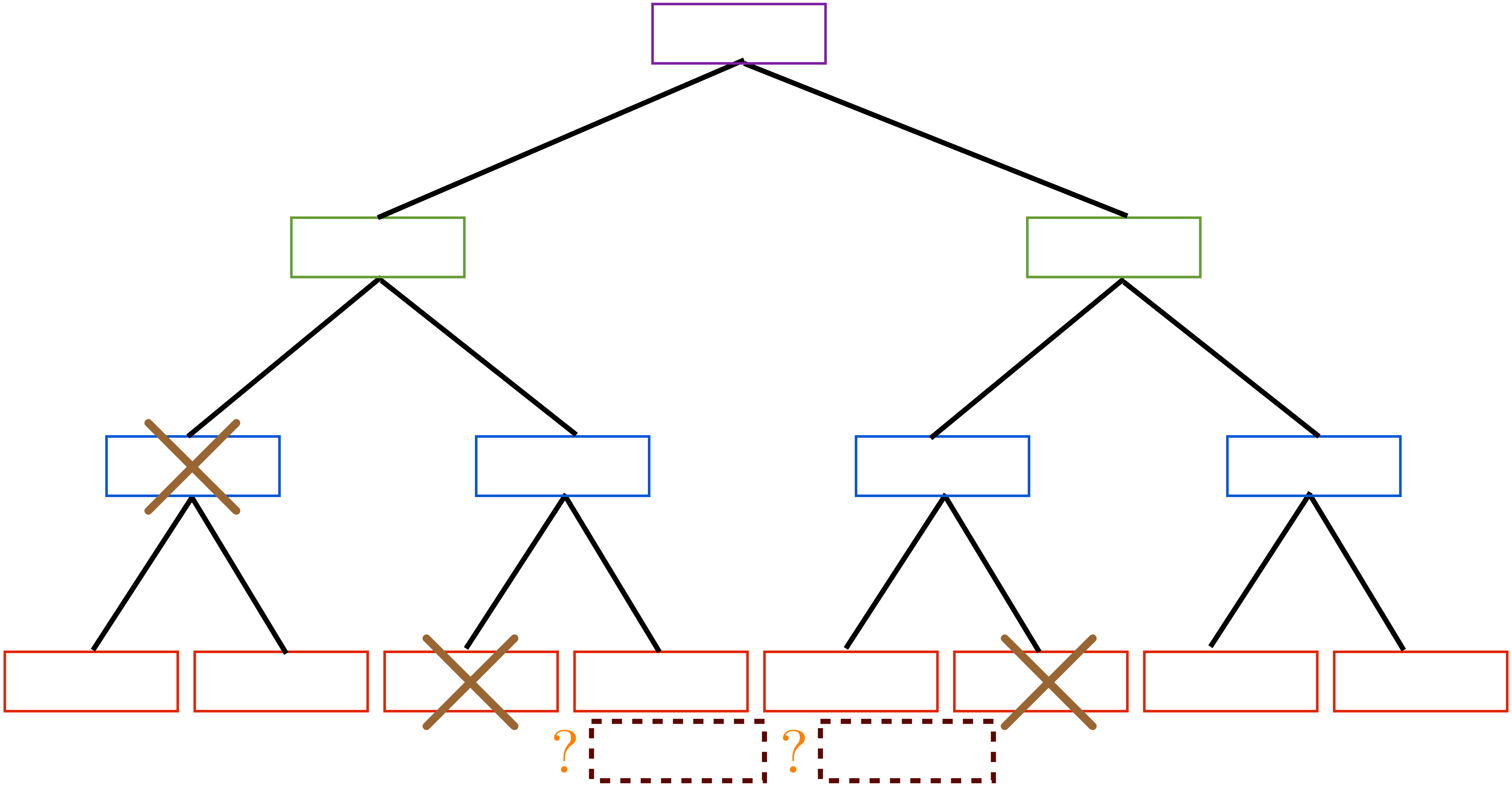

Collision detection (for simulated objects)

- Popular approach : Using axis-aligned bounding box (AABB) queries to accelerate collision detection
  - Prunes away most of the *"faraway"* collisions
  - Cost to check one primitive, against a box B-tree hierarchy with k leaves : O(logk) in the best case
    - Cost will increase if the box hierarchy is not optimally constructed (i.e. if we chose to merge faraway boxes)
    - Quality of hierarchy will degrade as object moves : May choose to re-build the hierarchy from scratch every few time steps
    - KD-Tree or Quad-/Oct-trees can be used to generate box hierarchies