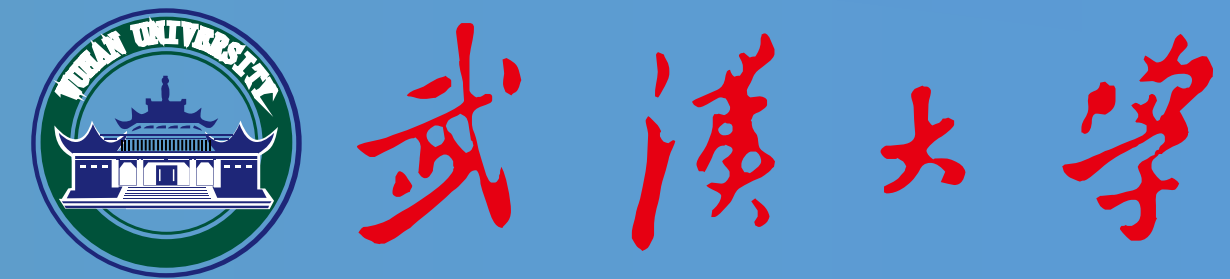# Road network extraction from satellite images using CNN based segmentation and tracing

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1. INTRODUCTION

- Traditional CNN based segmentation methods ignore topology of road networks and have shown serious problems on connectivity.

- Road tracing methods with single starting point are usually blocked by objects like bridges or viaducts, resulting in part areas unreached.

- We propose a **Multiple Starting Points Tracer** which benefits from both segmentation and tracing methods.

2. METHODOLOGY
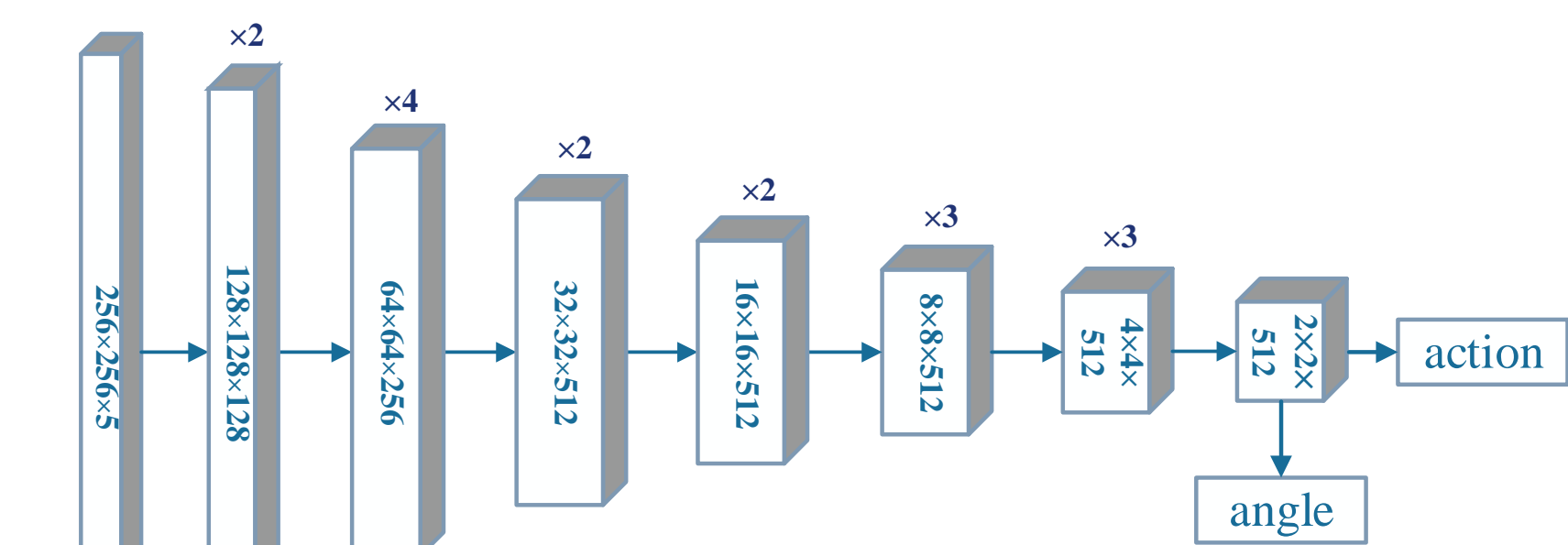
Our proposed method includes two stages：
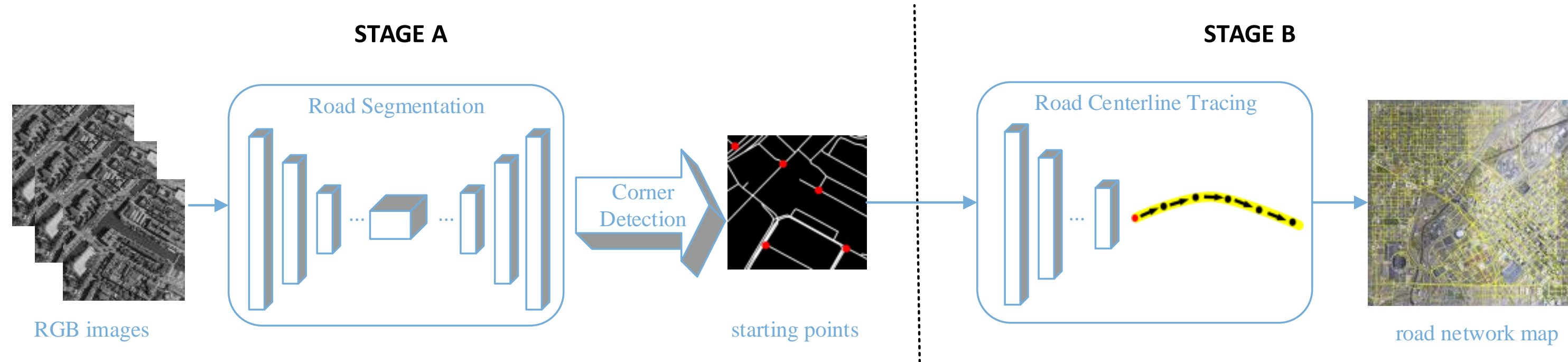
STAGE A: Generating Starting Points

√ Initial road segmentation by a fully convolutional network.

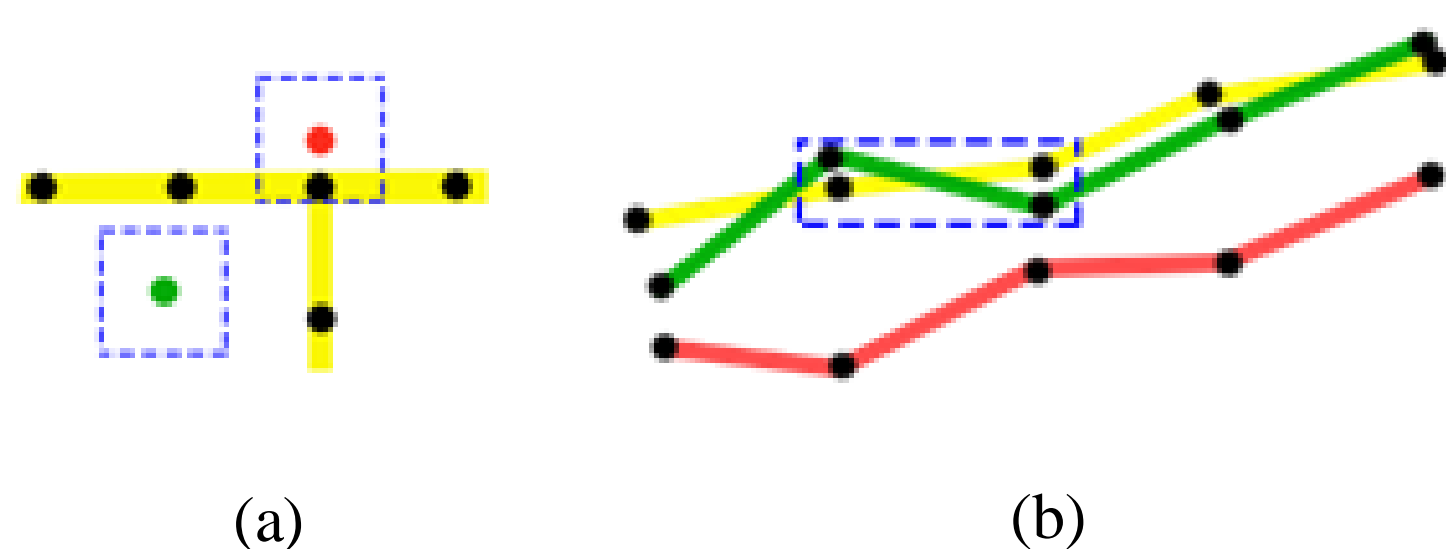√ Generating starting points from segmentation masks using corner detector.

STAGE B: RoadTracer with multi-starting points

√ An iterative search algorithm based on CNN is utilized to construct road networks.

Architecture of the CNN for road tracing.

√ Multiple points derived from STAGE A are used as starting points for road centerline tracing.

Two algorithms are proposed to improve searching results. (a) Adaptive Starting Point Decision (**ASPD**) algorithm. (b) Graph Merging (**GM**) algorithm.

Road Centerline Tracer with multiple starting points

Input: starting points list C, an initial graph array G_{array}, window W_i centered at C_i, threshold for GM algorithm T,
while C is not empty do
    random pick C_i from C
    initialize W_i centered at C_i
    if G_{array} intersect with W_i; break
    else
        G_i =centerline_tracing (C_i, Image)
        add G_i to G_{array}
    end if
    remove C_i from C
end while
random pick G_{base} from G_{array}
for G_i in G_{array}:
  for edge in G_i:
        if angle_difference(edge, G_{base}) > T then
            add edge to G_{base}
   end if
return G_{base}

3. EXPERIMANTAL RESULTS

Table I. Comparison of different methods on 12 cities

Method	F1-Score	IoU
RoadTracer	0.2692	0.1700
RoadTracer-S (ours)	0.2717	0.1725
RoadTracer-M (ours)	**0.3733**	**0.2575**

Table II. Quantitative Evaluation results (IoU) on four test cities

|	Chicago	Paris	Pittsburgh	Toronto
RoadTracer	0.17	0.15	0.05	0.26
RoadTracer-S (ours)	0.15	0.15	0.07	0.26
RoadTracer-M (ours)	0.31	0.24	0.28	0.48

(a)   (b)   (c)
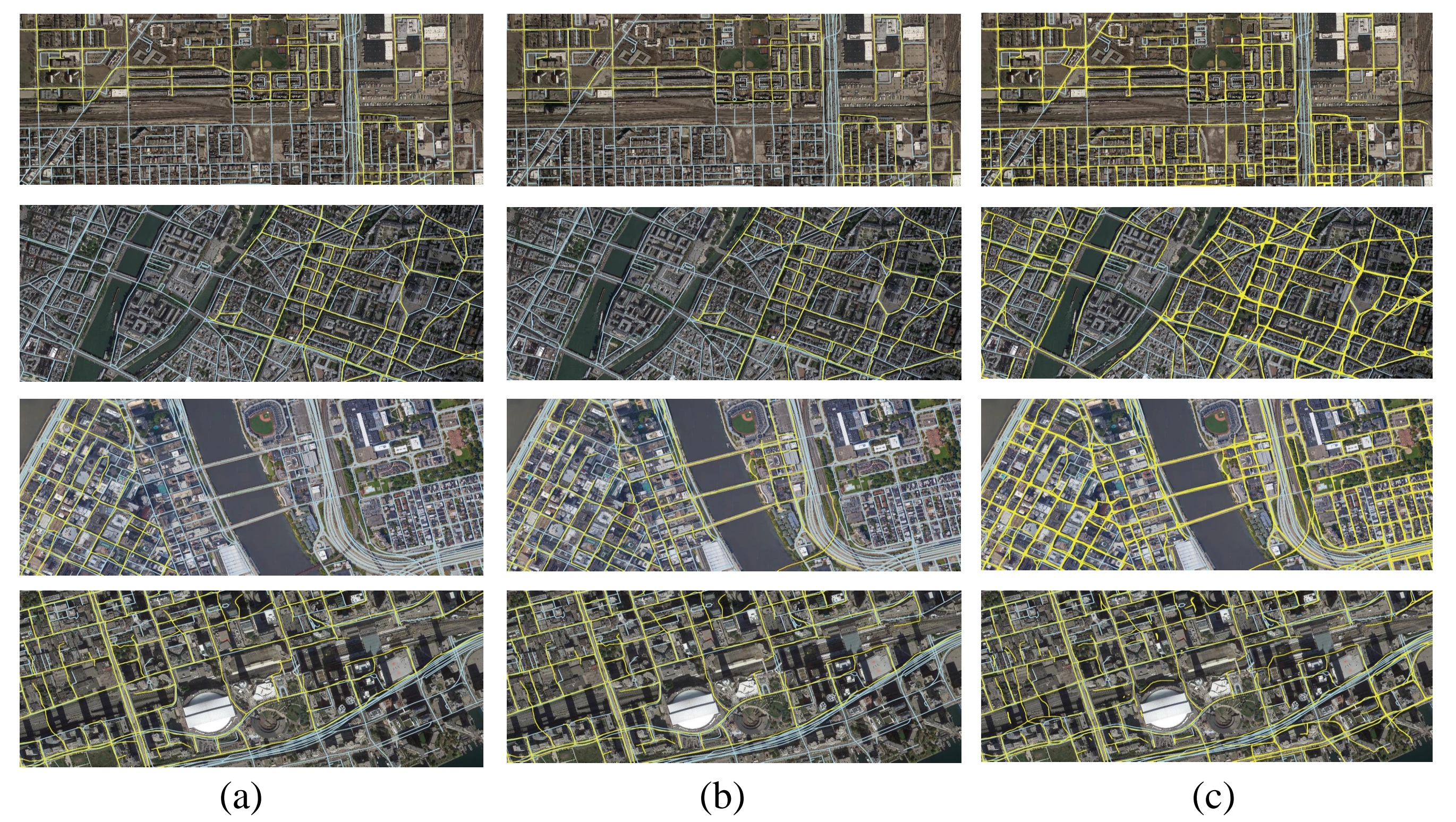
Comparison of results obtained by roadtracer from three types of starting points in four cities, Chicago (top), Paris, Pittsburgh, Toronto (bottom). **(a) RoadTracer. (b) RoadTracer-S. (c) RoadTracer-M.** We overlay predicted graph (yellow) over OSM ground truth (light blue).

4. CONCLUSION

In this paper, we present an approach which integrates CNN based road segmentation and road centerline tracing. Segmentation result is utilized to assist tracing by generating multiple starting points. Besides, two optimizing methods are proposed to reduce computing cost and improve final results.

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Our latest research on road extraction from remote sensing images: **A multistage framework for simultaneously road segmentation and centerline extraction.**
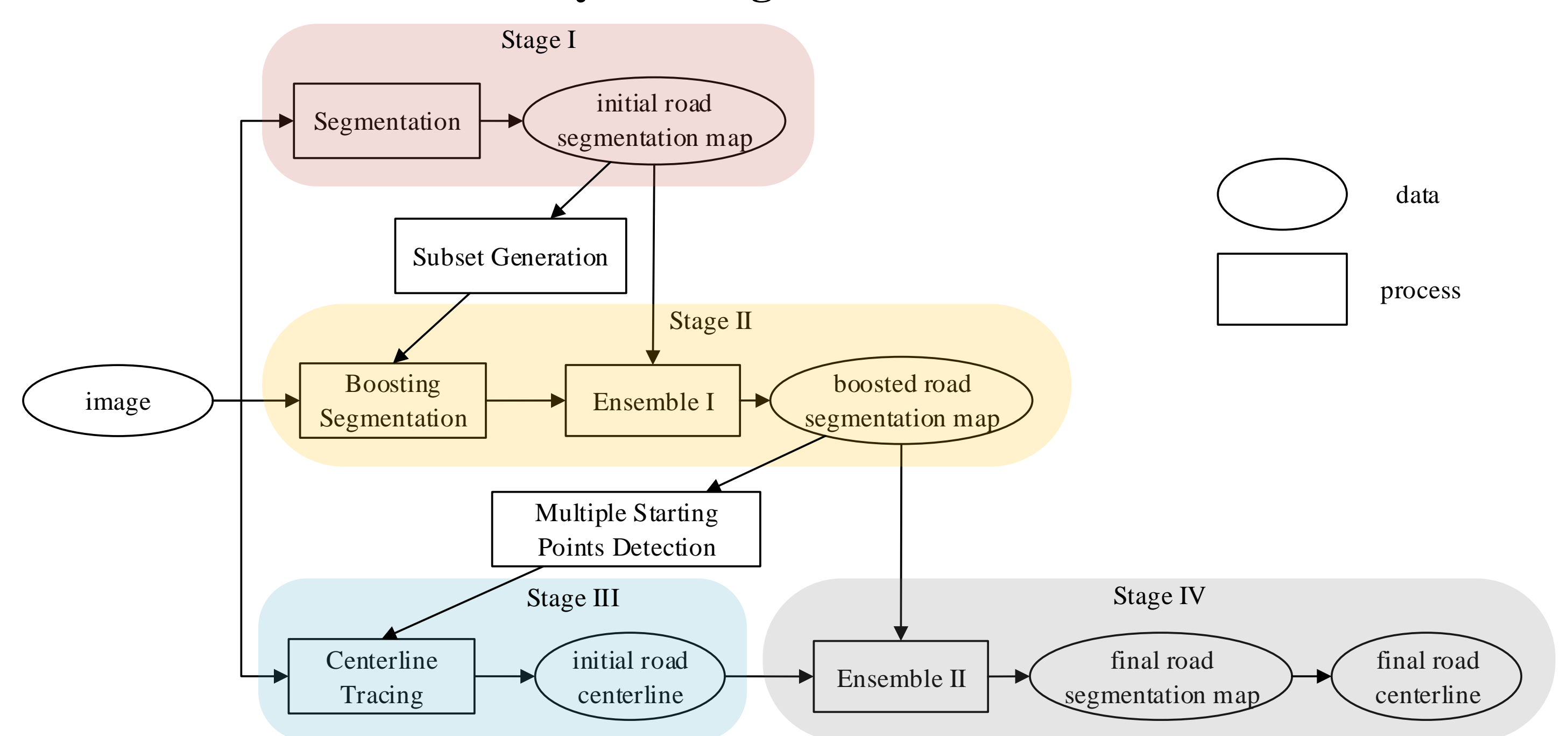
Overview of the proposed multistage framework for road extraction
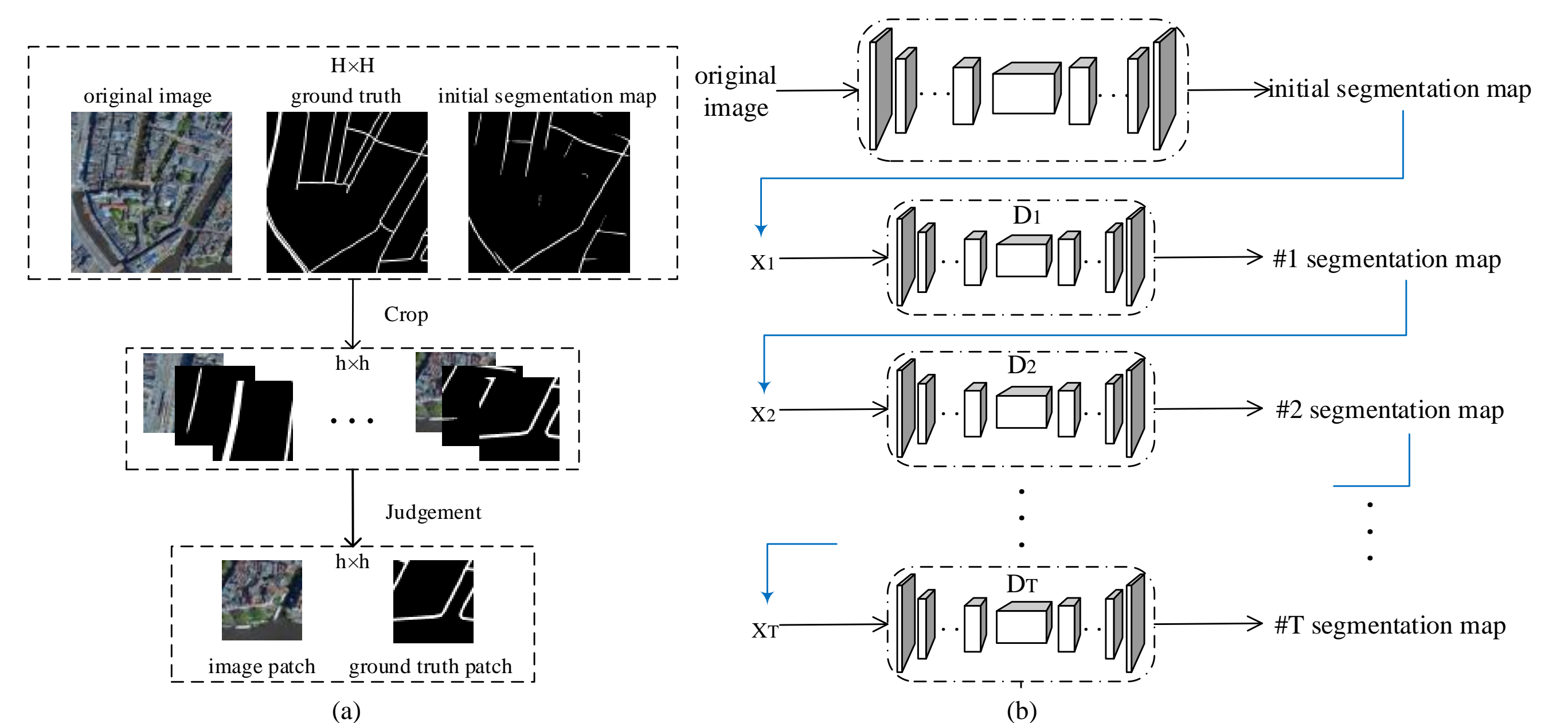
The flowchart of boosting segmentation.