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Interactive Optimization for Cartographic Aggregation of Building Features (Supplementary Material)

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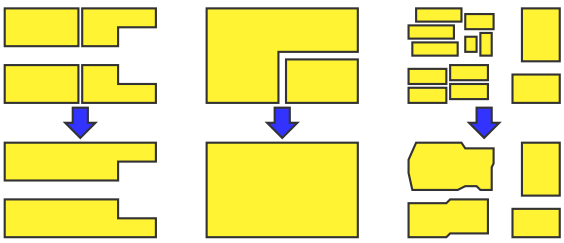
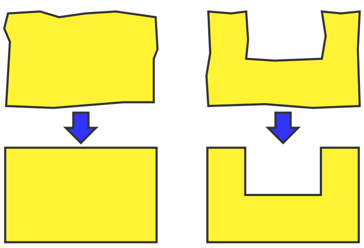
Appendix A: Guidelines for Aggregation and Simplification

We summarize the guidelines for aggregation and simplification derived from our observation of old Japanese maps at different scales, as depicted in Figures 12 and 13, respectively.



(a) (b) (c)

Figure 12: *Aggregation rules. (a) (A1) Boundaries of building features are sufficiently close to each other. (b) (A2) Combinations of building features form a simple shape. (c) (A3) Spatial density of building features becomes low.*



(a) (b)

Figure 13: *Simplification rules. Building features are simplified into (a) (S1) Rectangular shapes and (b) (S2) Shapes with a small number of corners.*

Appendix B: Pruning the Proximity Graph

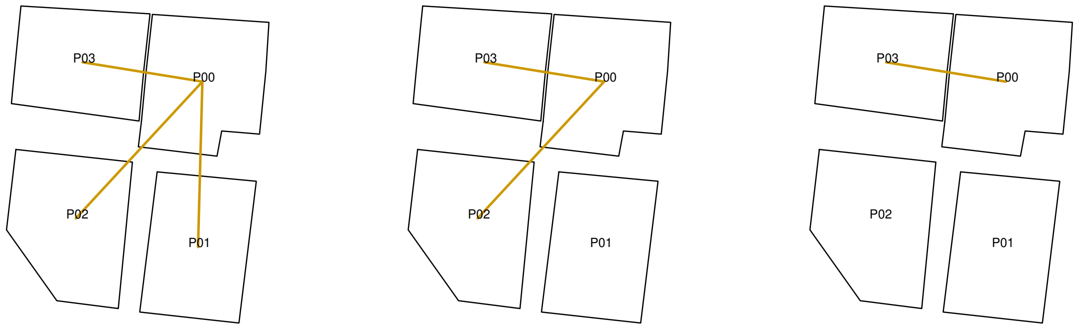
As described in Section 4.2, we contracted the initial proximity graph to collect groups of building features. This was accomplished by gradually reducing the threshold interval, for example, by 10% of the initial threshold value. Figure 14 shows how we pruned the edges of the initial proximity graph for the example in Figure 3. Note that we collected group label L04 in Table 1 from the initial proximity graph in Figure 3b, L05 from the contracted graph in Figure 14b, and L06 from the contracted graph in Figure 14c. Conversely, the contracted graph in Figure 14a does not yield any new groups since the connected component covers the same set of building features as in Figure 3b. Also note that group label L07 comes from the law of similarity, as described in Section 4.2.

Appendix C: Interactive Aggregation for a Complex Case

In this appendix, we present how our approach can aggregate the building layout in the city block shown in Figure 1 compared to the simple case demonstrated in Section 4. Note that in this case, we explored a set of feasible aggregation pattern for the 11 building features.

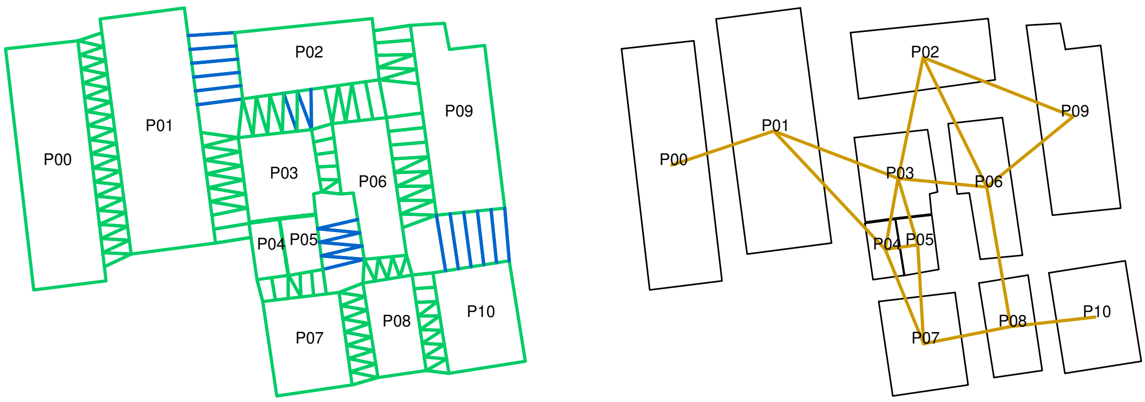
Figure 15 shows the β-skeleton and the proximity graph over the building features in the complex city block. As in Figure 3, green edges indicate interval distances less than the threshold value, and blue edges correspond to distances greater than the threshold value. Table 3 shows possible building group labels for the complex example case. Here, L11–L14 come from the law of proximity and L15 and L16 from the law of similarity. Table 4 lists the data, smoothness, and label costs for 11 building features (P00 - P10) and 16 group labels (L00 - L15) for the complex city block in Figure 1. In Table 4, the upper bounds for data cost, smoothness cost, and label cost are 9.0, 5.0, and 6.5, respectively.

Figure 16 shows how the label assignment was updated as the optimization proceeded. In this case, we began from the original layout of building features (A), reduced the total energy by replacing labels step by step through (B) to (E), and then arrived at the global minimum (F). As in Figure 4 and Table 2, we again used



(a) **(b)** **(c)**

Figure 14: *Contracting the proximity graph to collect groups of building features. The threshold interval becomes (a) 90%, (b) 80%, and (c) 60% of the initial threshold value. Group labels L05 and L06 in Table 1 come from the contracted graphs in (b) and (c), respectively.*



(a) **(b)**

Figure 15: *Proximity graph composition. (a) A* β*-skeleton for evaluating the distance between building features and (b) its associated proximity graph. PXX represents the building ID XX.*

color tags to represent correspondences between the aggregation patterns of building features and costs to be penalized. This time, we had six aggregation patterns in total and thus introduced six color tags as shown in Figure 16. This allowed us to calculate the total cost for each aggregation pattern as we did with Figure 4 and Table 2.

Figure 17 demonstrates an operation of forcing the aggregation of certain features in the case of the complex city block. Even with this complex case having 11 building features, we still achieved the aggregation for a specific set of building features.

Appendix D: Area-preserving edge-move simplification

As described in Section 5.2, we implemented the area-preserving edge-move algorithms formulated by Buchin et al. [BMS11], in which we introduced minor improvements for our objectives. Figure 18 depicts how each pair of edge moves reduce the complexity of the contour shape that encloses an aggregated set of building polygons. The fundamental idea is to find a pair of contour edges that sweep large areas around the contour (Figure 18a) and translate them to reduce the number of corner vertices along the contour while preserving the area (Figure 18b). Refer to [BMS11] for further details.

References

[BMS11] Buchin K., Meulemans W., Speckmann B.: A new method for subdivision simplification with applications to urban-area generalization. In *Proceedings of the 19th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems* (2011), pp. 261–270. doi:10.1145/2093973.2094009. 2, 4

Table 3: *Group labels assigned to the buildings in the example city block example. PXX indicates the building ID XX, and LXX indicates the label ID XX. Each check mark indicates that the corresponding buildings (PXX) are contained in a specific group label (LXX).*

	L00	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	L12	L13	L14	L15	L16
P00	✓											✓	✓				
P01		✓										✓	✓				
P02			✓									✓					
P03				✓								✓		✓	✓		
P04					✓							✓		✓	✓	✓	
P05						✓						✓		✓	✓	✓	
P06							✓					✓		✓			
P07								✓				✓		✓			✓
P08									✓			✓		✓			✓
P09										✓		✓					
P10											✓	✓		✓			

	Total	**D**	**S**	**L**	P00	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
(A)	43.8	11.0	21.8	11.0	L00	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10
(B)	41.3	20.0	13.8	7.5	L00	L01	L02	L03	L16	L16	L06	L16	L16	L09	L10
(C)	38.8	15.0	15.8	8.0	L00	L01	L02	L03	L15	L15	L06	L16	L16	L09	L10
(D)	36.5	16.0	12.0	8.5	L00	L01	L02	L14	L14	L14	L06	L16	L16	L09	L10
(E)	57.8	18.0	7.0	10.4	L00	L01	L02	L13	L13	L13	L13	L13	L13	L09	L13
(F)	55.8	22.0	0.0	6.5	L11	L11	L11	L11	L11	L11	L11	L11	L11	L11	L11

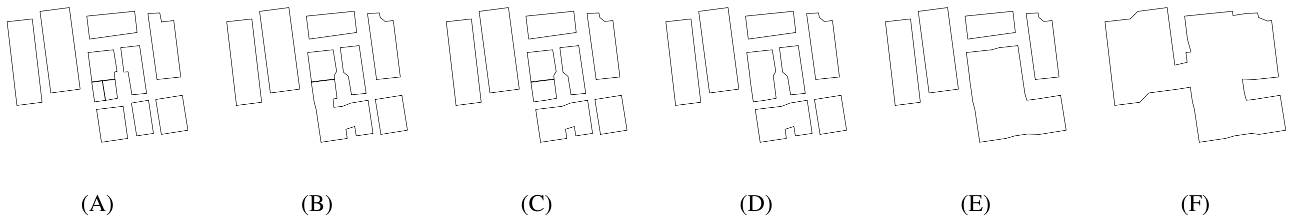


Figure 16: *Changes in the label assignment $f_p(\in \mathcal{L})$ in the 11 building features $p(\mathcal{P})$ for the example city block. Here,* ***D****,* ***S****, and* ***L*** *denote the data cost, smoothness cost, and label cost, respectively. Note that the total energy decreases as the optimization proceeds.*

Figure 17: *An operation to force manually selected features to be aggregated in the case of complex city block. (a) The initial set of aggregation patterns. (b) Two features on the right are selected as a group using a rubber-band interface. (c) The updated set of aggregation patterns.*

Table 4: *Costs for the building features in the complex city block. (a) Data (**D**), (b) smoothness (**S**), and (c) label (**L**) costs. The color tags show correspondences with the costs in Figure 16.*

D	L00	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	L12	L13	L14	L15	L16
P00	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.0	2.0	6.6	9.0	9.0	8.2
P01	9.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.0	2.0	5.7	8.4	8.8	8.0
P02	9.0	9.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.0	5.2	4.1	7.3	8.5	7.5
P03	9.0	9.0	9.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.0	4.4	2.0	2.0	6.8	6.2
P04	9.0	9.0	9.0	9.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	2.0	3.9	2.0	2.0	2.0	4.5
P05	9.0	9.0	9.0	9.0	9.0	1.0	9.0	9.0	9.0	9.0	9.0	2.0	4.5	2.0	2.0	2.0	4.5
P06	9.0	9.0	9.0	9.0	9.0	9.0	1.0	9.0	9.0	9.0	9.0	2.0	5.9	2.0	6.4	7.9	6.0
P07	9.0	9.0	9.0	9.0	9.0	9.0	9.0	1.0	9.0	9.0	9.0	2.0	5.9	2.0	6.1	7.4	2.0
P08	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	1.0	9.0	9.0	2.0	6.4	2.0	6.1	7.4	2.0
P09	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	1.0	9.0	2.0	6.9	4.4	8.6	8.8	7.6
P10	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	1.0	2.0	7.1	2.0	8.3	8.5	5.1

(a)

S	P00	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
P00		1.0									
P01				1.0	1.0						
P02				1.0			1.0			1.0	
P03					1.7	2.1	1.0				
P04						5.0		1.0			
P05								1.0			
P06									1.0	1.0	
P07									1.0		
P08											1.0
P09											
P10											

(b)

L	L00	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	L12	L13	L14	L15	L16
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.5	4.0	6.4	2.0	0.5	0.5

(c)

(a) **(b)**

Figure 18: *Area-preserving edge-move simplification [BMS11]. Contour polygon shapes (a) before and (b) after a single edge-move operation.*