Road Planning for Slums via Deep Reinforcement Learning

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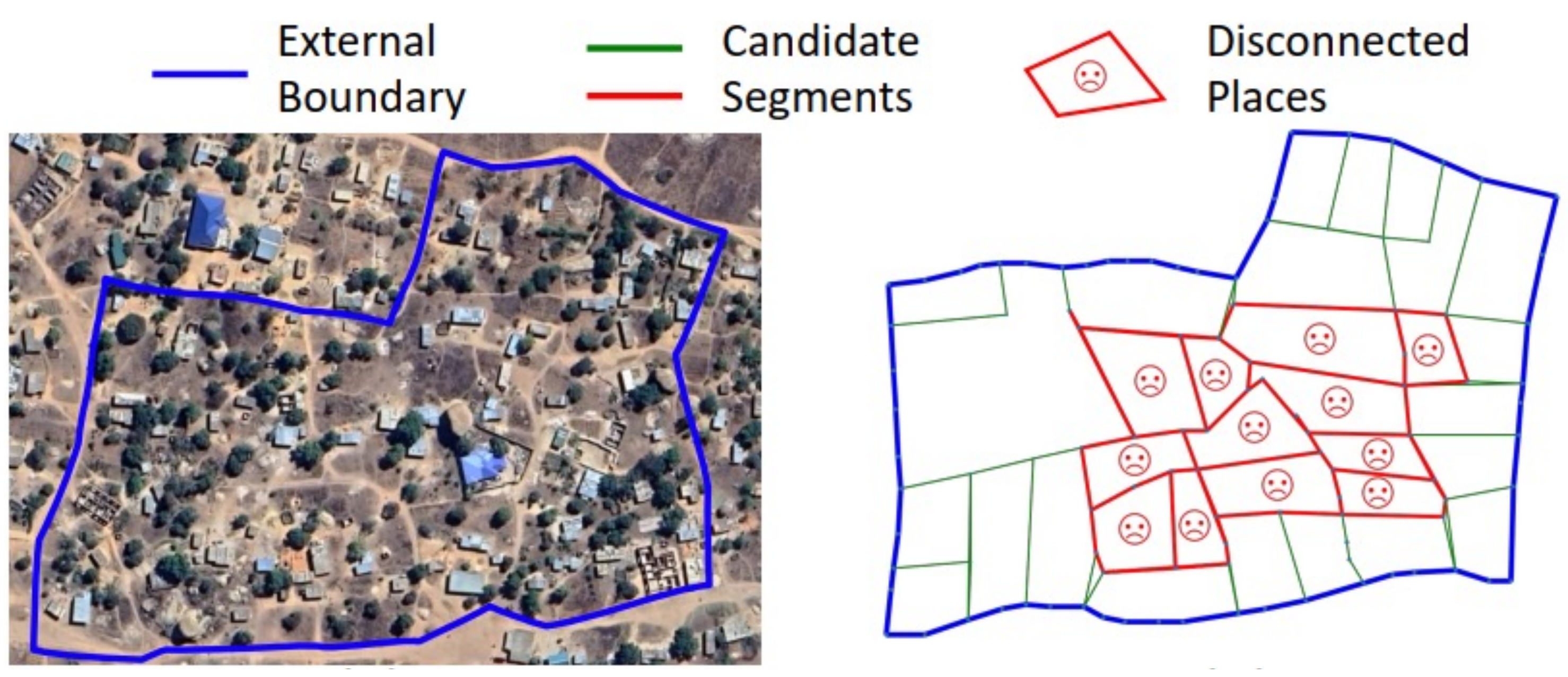
Slums, Roads, and Accessibility

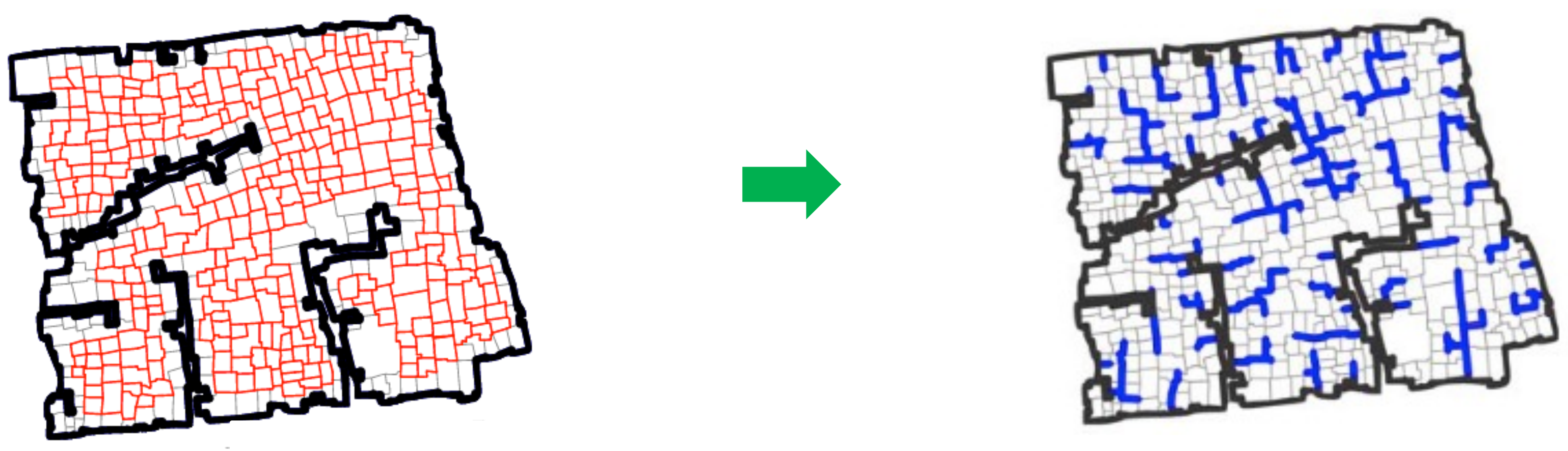


Poor accessibility: internal places not connected to external road systems

- ➢ Unreachable by vehicles: ambulance, fire fighting trucks, …
- ➢ Undeliverable services: piped service of water and sanitation

inadequate road infrastructure -> severe problems in public health, environment, etc.

Road Planning for Slums



Goals:

- ➢ **To deliver basic services:** grow a minimal road network, making all places connected to roads (**universal connectivity**)

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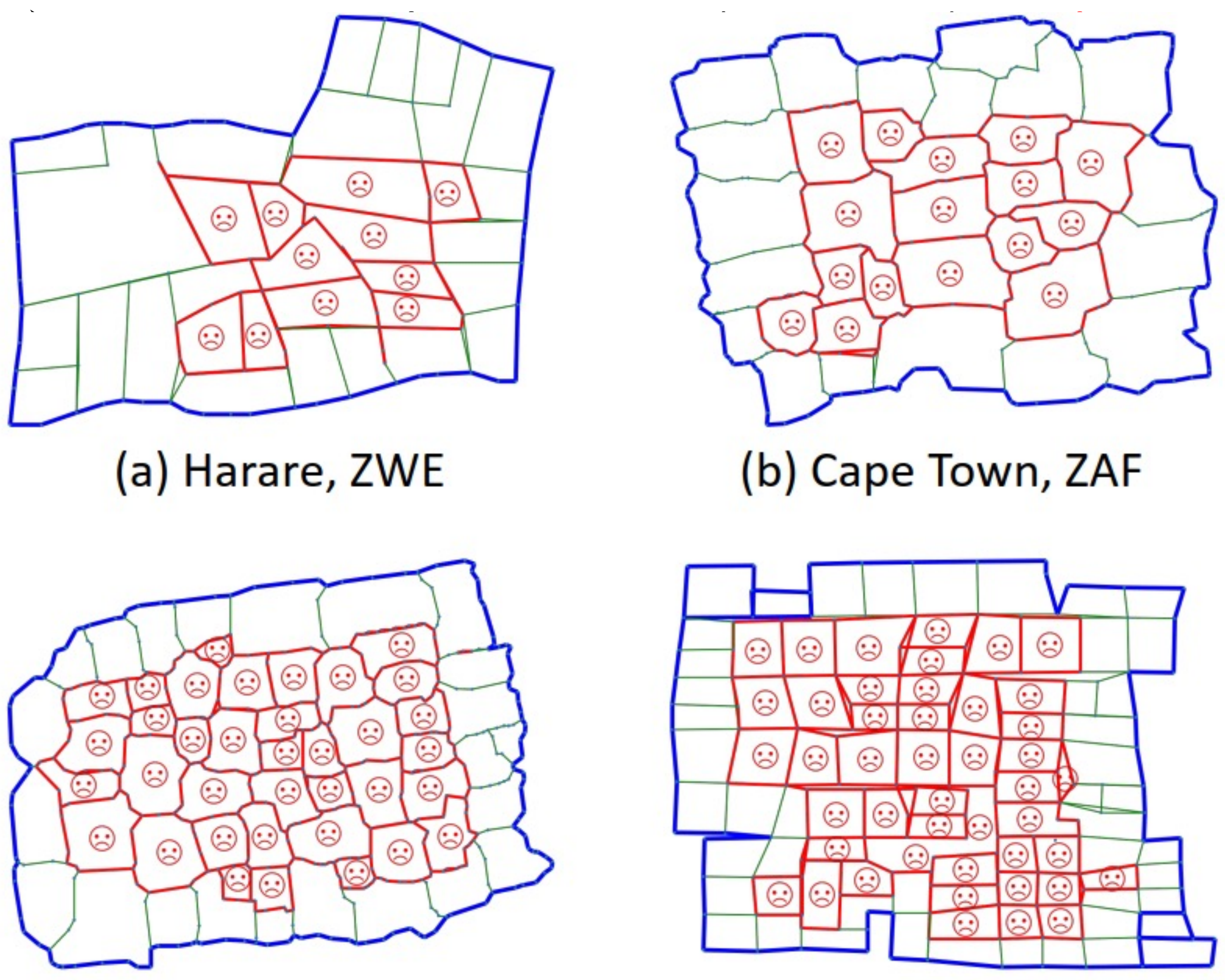
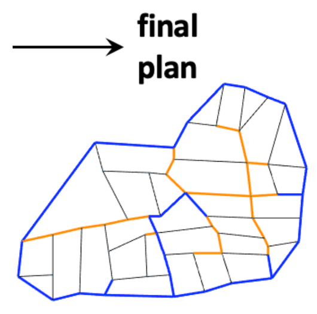


(a) Harare, ZWE (b) Cape Town, ZAF

(c) Cape Town, ZAF (d) Mumbai, IND

R ... **g Problem**



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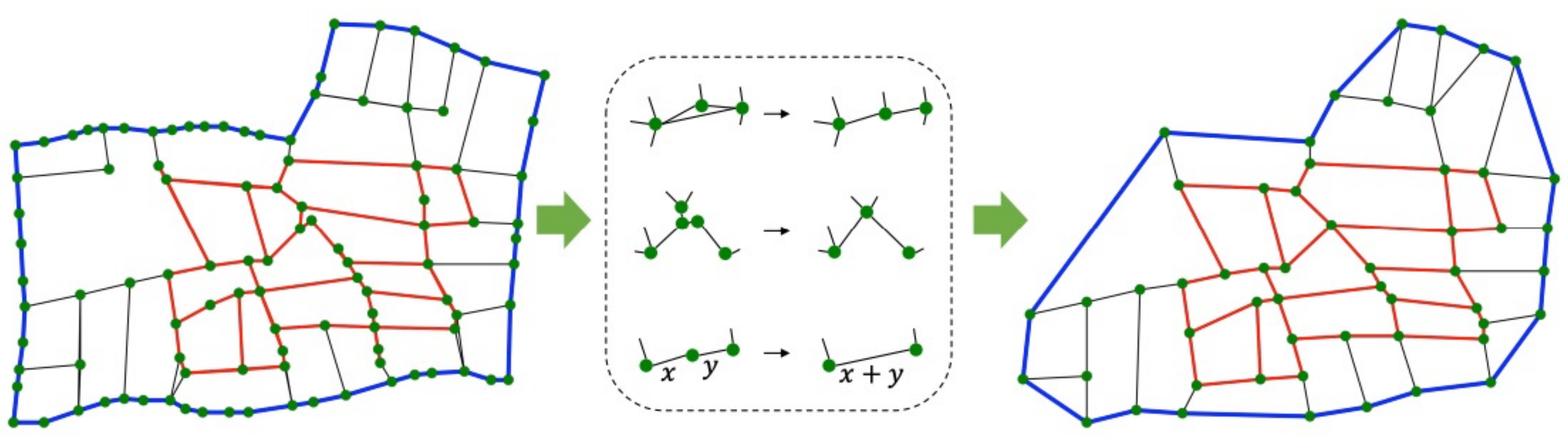
r the road network $E \cup R$.

(3) Minimizing the overall construction cost for the road plan $\sum_{i \in R} C_i$

Stage I: achieve universal connectivity
Stage II: reduce travel distance
At each step: one road segment is planned at a specific location

Solving the Problem from Topology instead of Geometry

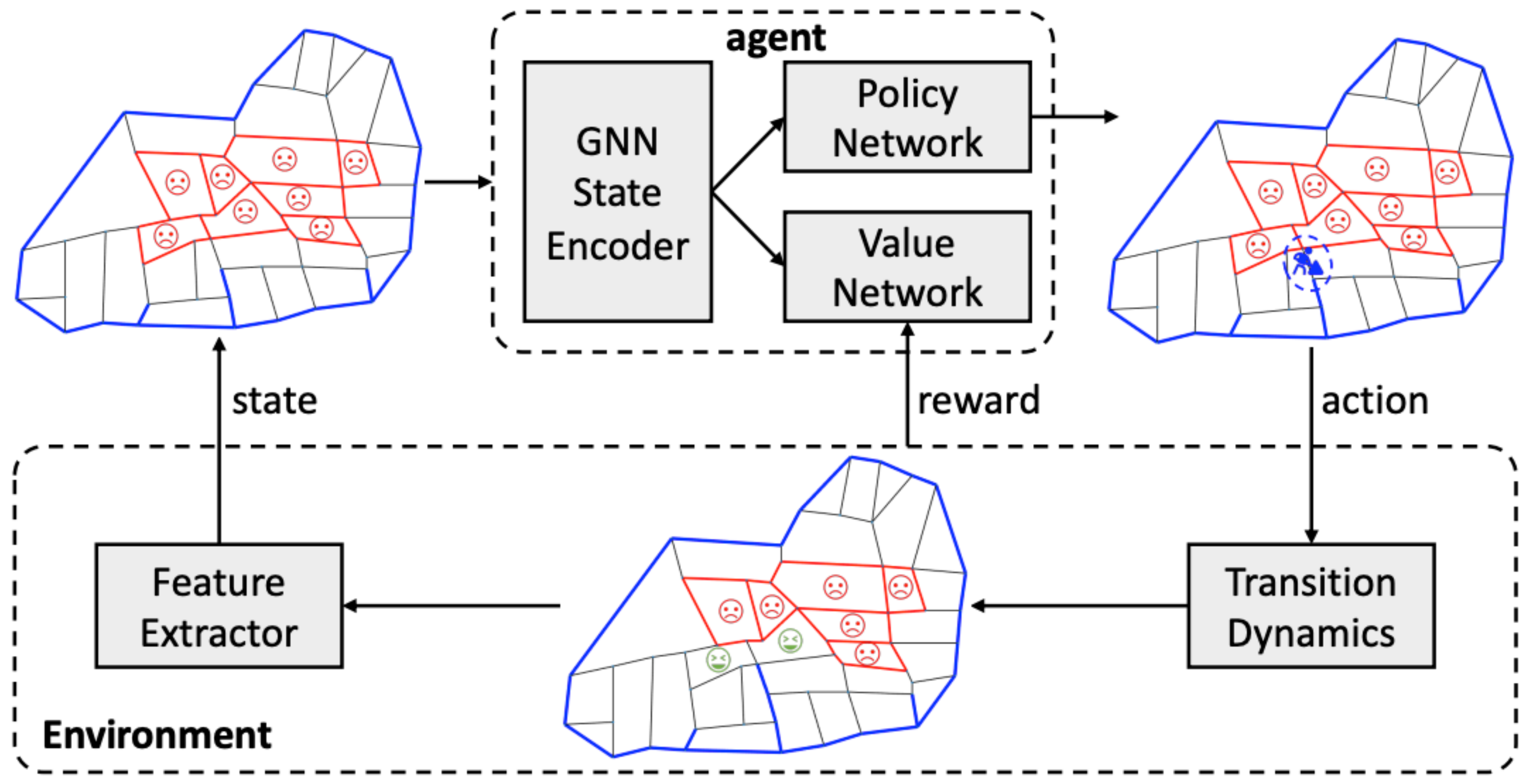


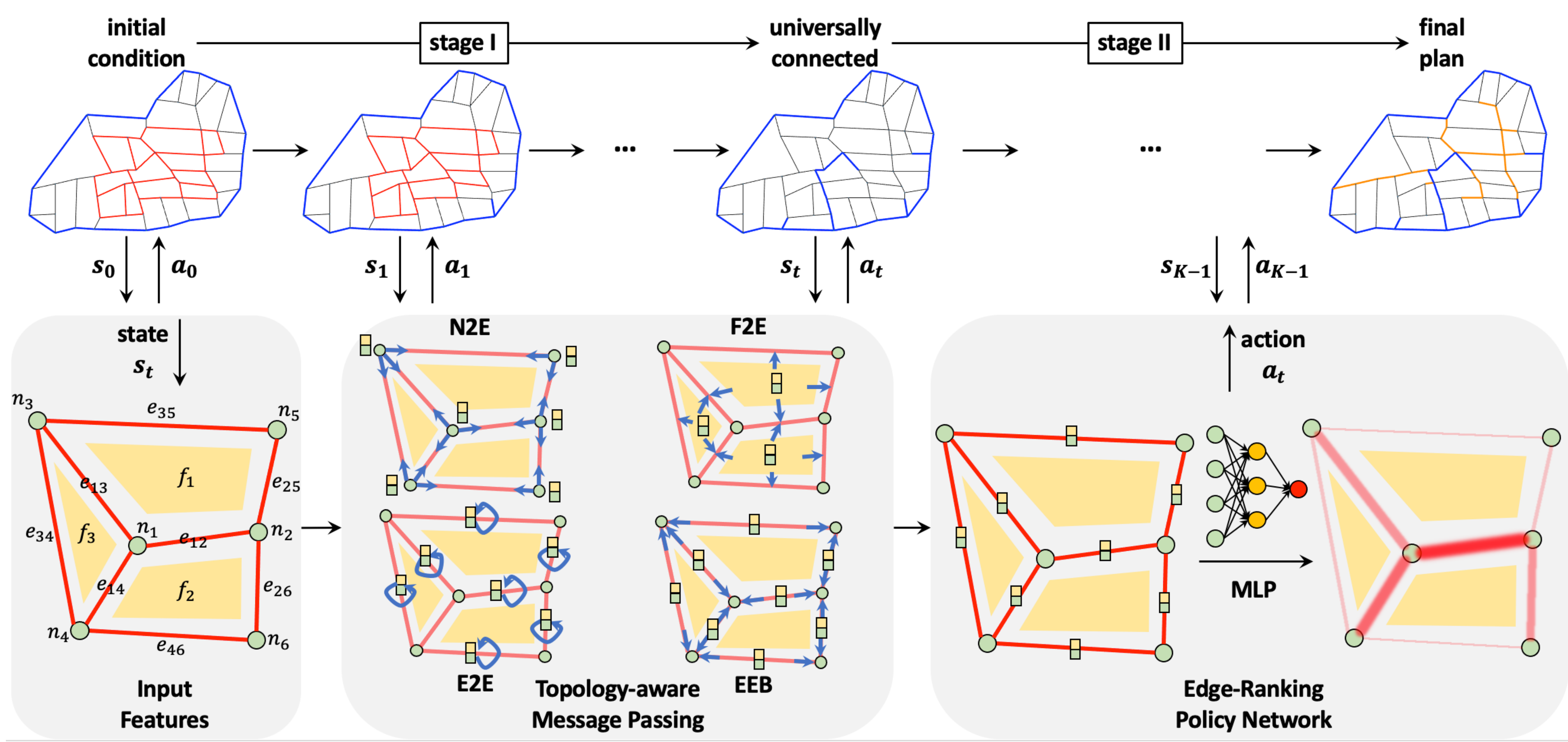
- ➢ **construct a planar graph based on the original geometrical descriptions**
- ➢ polygons (places) -> faces
- ➢ segments (roads/spacing) -> edges
- ➢ junctions -> nodes

road planning: selecting edges on a dynamic graph

Our Model

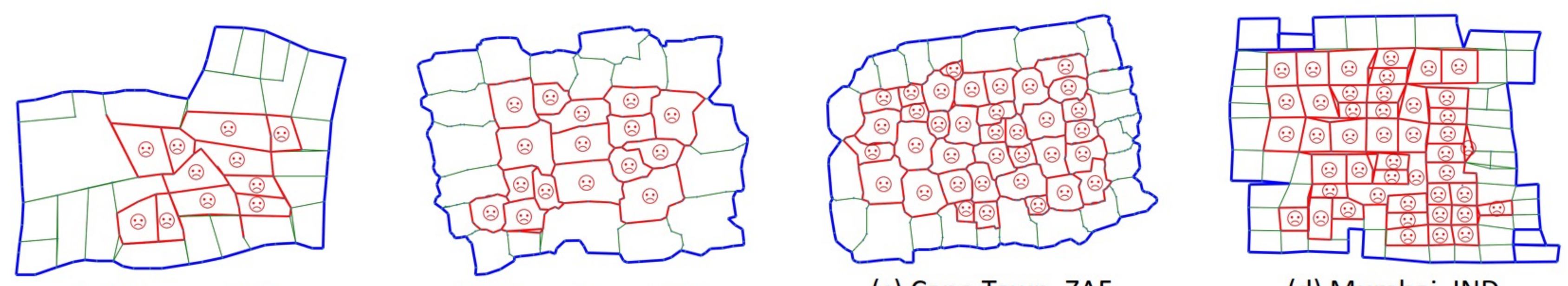
A Deep Reinforcement Learning Model with Graph Neural Networks





Results

Experimented slum data

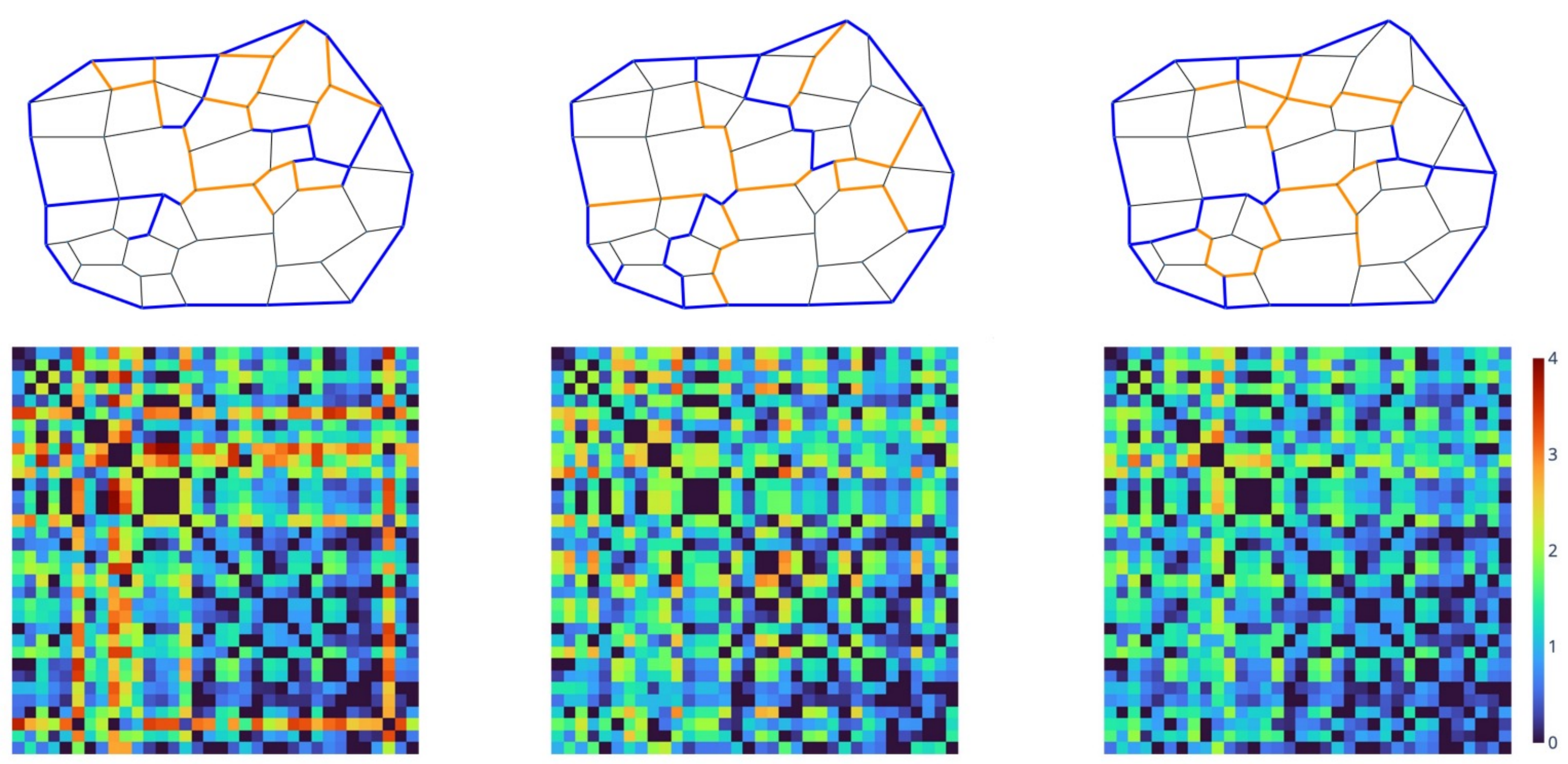


(a) Harare, ZWE (b) Cape Town, ZAF (c) Cape Town, ZAF (d) Mumbai, IND

Comparison with existing approaches

Method	Harare, ZWE			Cape Town, ZAF (A)			Cape Town, ZAF (B)			Mumbai, IND		
	NR	AD	SC	NR	AD	SC	NR	AD	SC	NR	AD	SC
Random	29	1.06	6.30	F	INF	10.83	F	INF	20.76	F	INF	26.05
Random (masked)	10	1.00	6.13	14	1.62	10.37	54	2.77	19.95	42	2.50	24.92
Greedy-A (masked)	8	0.63	5.04	13	1.12	10.42	28	1.66	18.91	29	1.77	25.42
Greedy-C	20	0.84	3.85	35	1.83	7.03	F	INF	14.10	F	INF	19.45
Greedy-C (masked)	11	0.84	3.85	14	1.81	7.23	35	2.22	14.29	45	2.81	19.28
GA-G (masked)	11	0.58	4.60	14	1.14	8.72	34	1.99	18.95	42	1.87	24.26
GA-S (masked)	-	0.58	5.25	-	1.21	8.44	-	1.89	17.72	-	1.88	23.22
HS-MC (masked)	13	0.62	5.31	16	1.09	9.09	37	1.55	16.98	43	1.61	23.00
DRL-MLP (ours, masked)	11	0.52	**4.38**	14	0.96	8.28	32	1.57	15.66	31	1.52	22.93
DRL-GNN (ours, masked)	**9**	**0.50**	4.60	**13**	**0.93**	**8.24**	**31**	**1.51**	**15.62**	**29**	**1.51**	**22.82**
impr% v.s. HS-MC	-25.0%	-19.4%	-17.5%	-18.8%	-14.7%	9.8%	-16.2%	-2.6%	-8.0%	-32.6%	-6.21%	-0.8%
Build All Roads	-	0.47	11.50	-	0.80	19.82	-	1.21	37.55	-	1.36	49.25

Generated road plans and their corresponding travel distance



(a) GA-G (b) HS-MC (c) DRL-GNN