Automatically repairing polygons and planar partitions with *prepair* and *pprepair*

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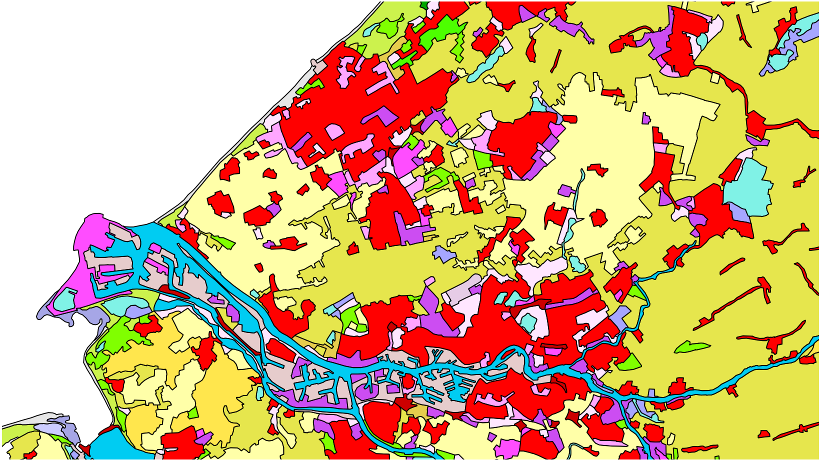
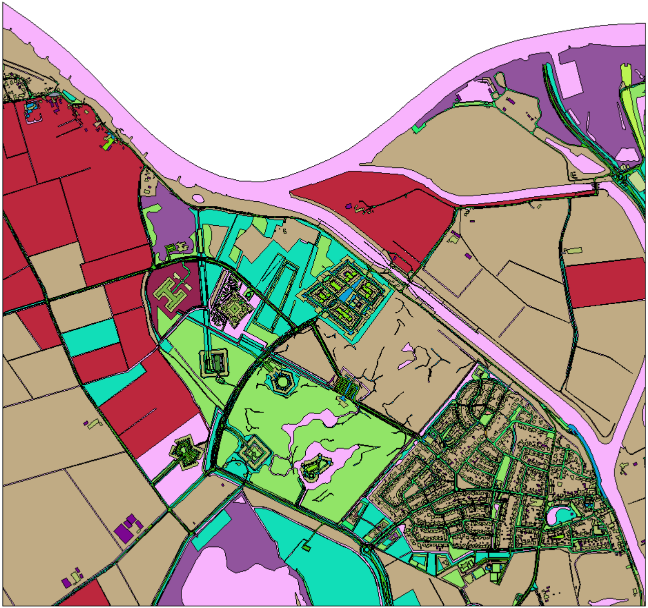
Planar partition = no gaps, no overlaps



Real data = problems



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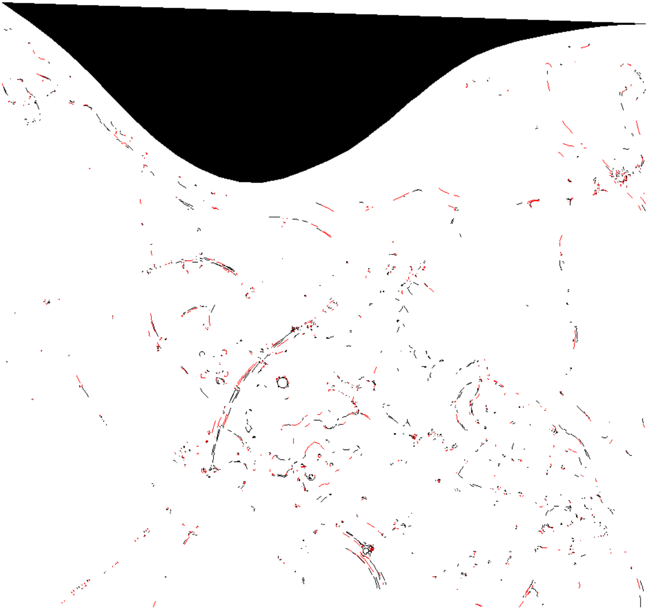
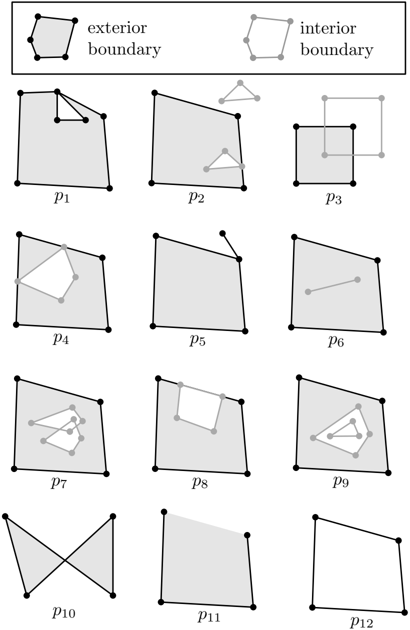


What about polygons?

OGC Simple Features + ISO19107:

1. no self-intersection
2. closed boundaries
3. rings can touch but not overlap
4. no duplicate points
5. no dangling edges
6. connected interior



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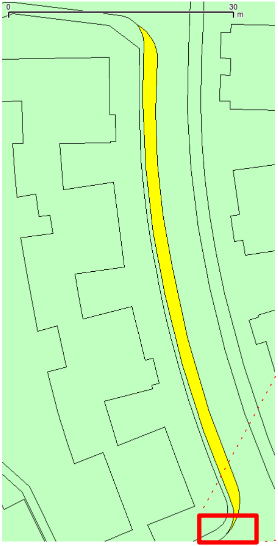

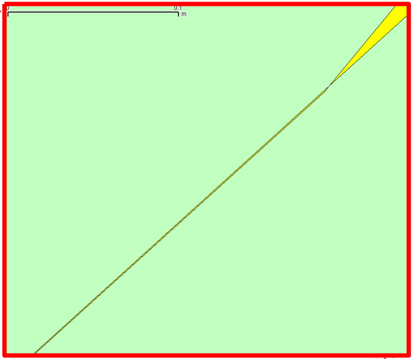

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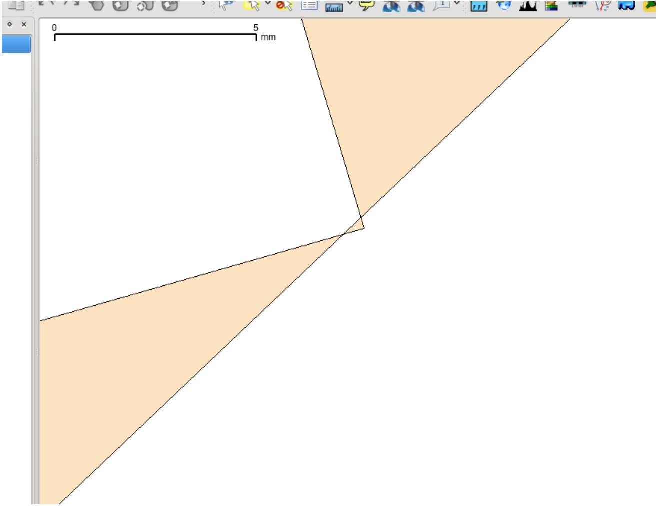

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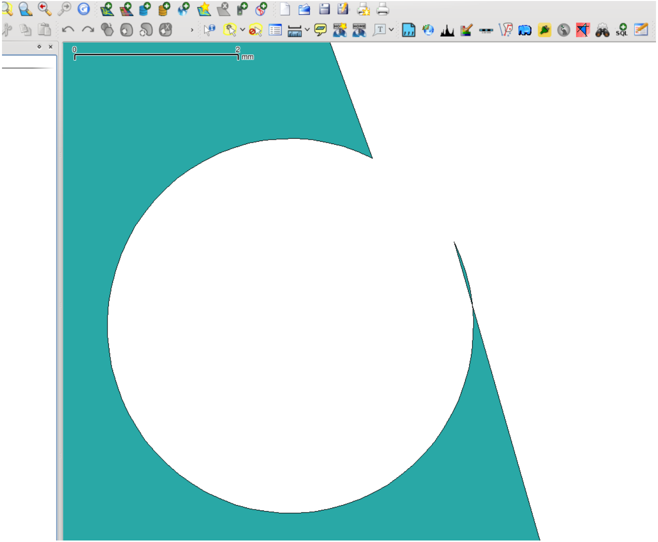
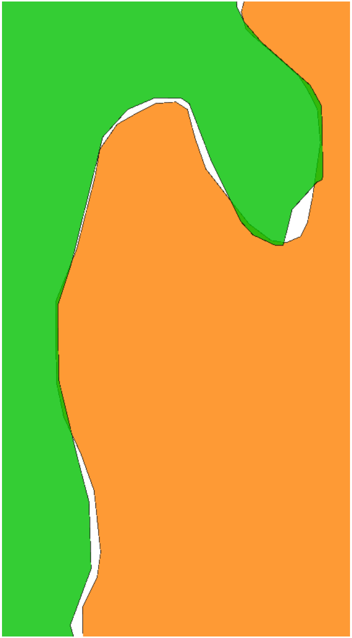


Standards/definitions tell us what is valid, but...
what to do with invalid data?

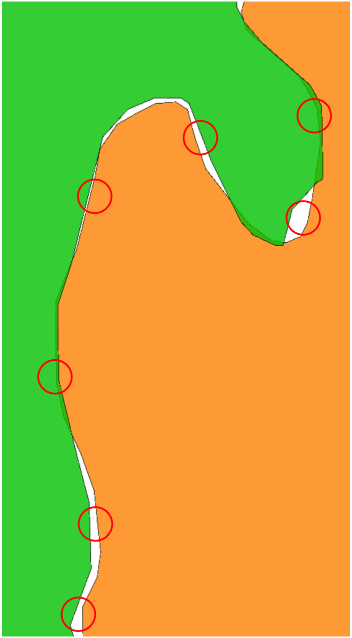
- Planar partitions: snapping / topology rules / manual work
- Polygons: "buffer-by-0" / PostGIS 2.0's ST_MakeValid() / "visual repair"

Snapping



- Tolerance (*threshold*) is used for *snapping* vertices
- Tolerance based on scale of datasets
- Works fine for *simple* problems

Snapping



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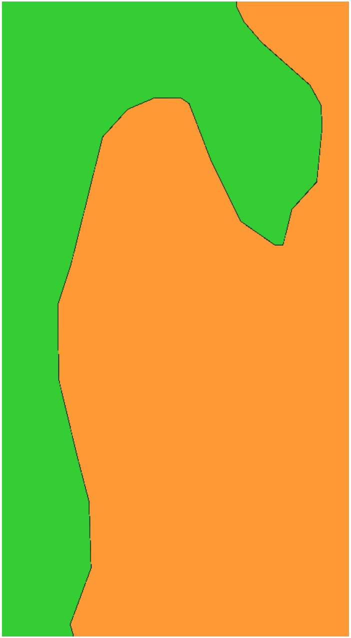

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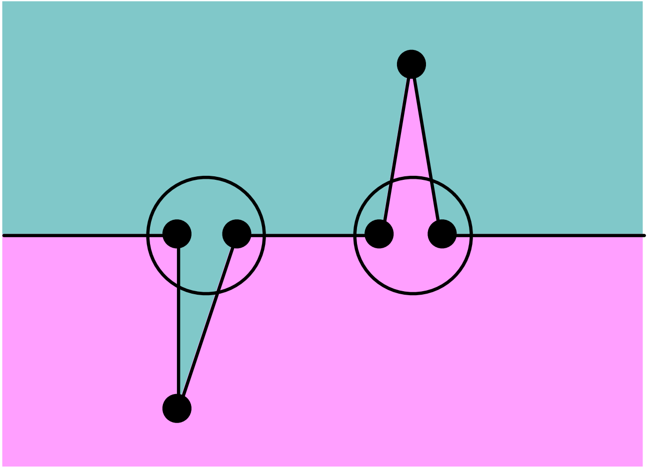
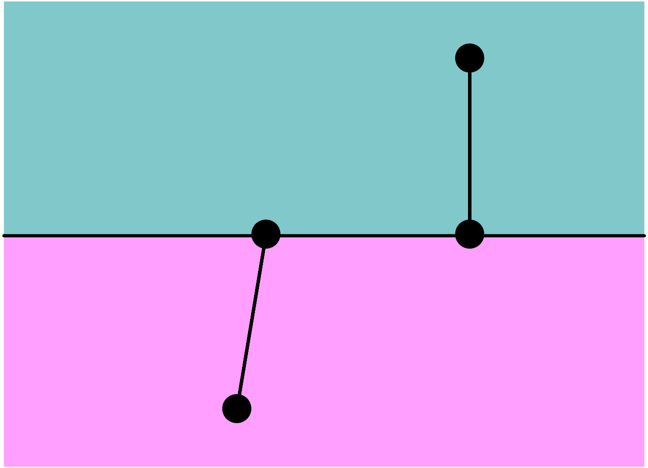


Spikes and punctures can create invalid polygons

Snapping



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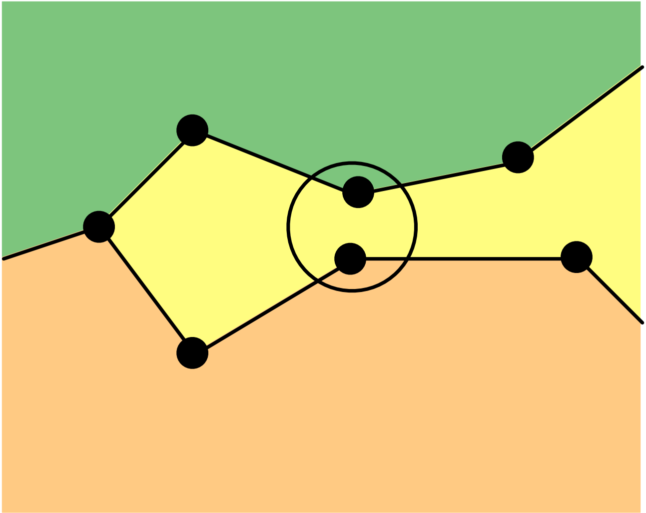
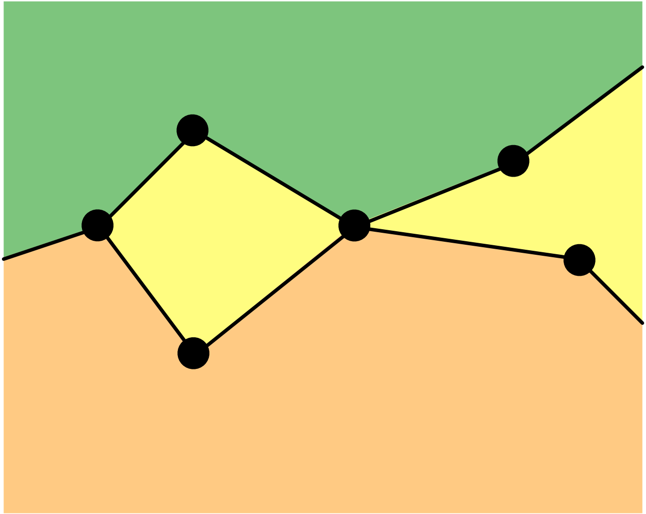


Splitting of polygons into several polygons

Snapping



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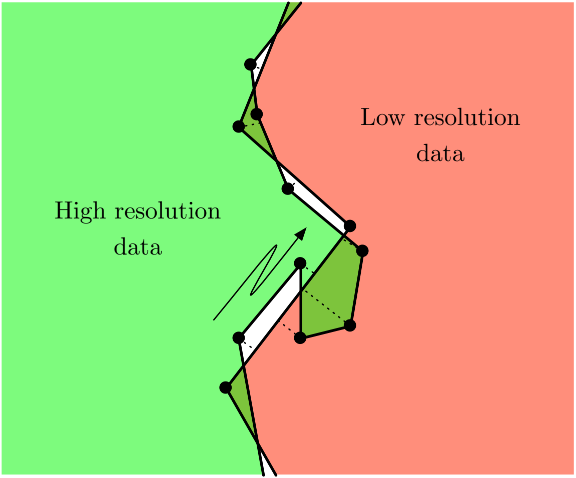
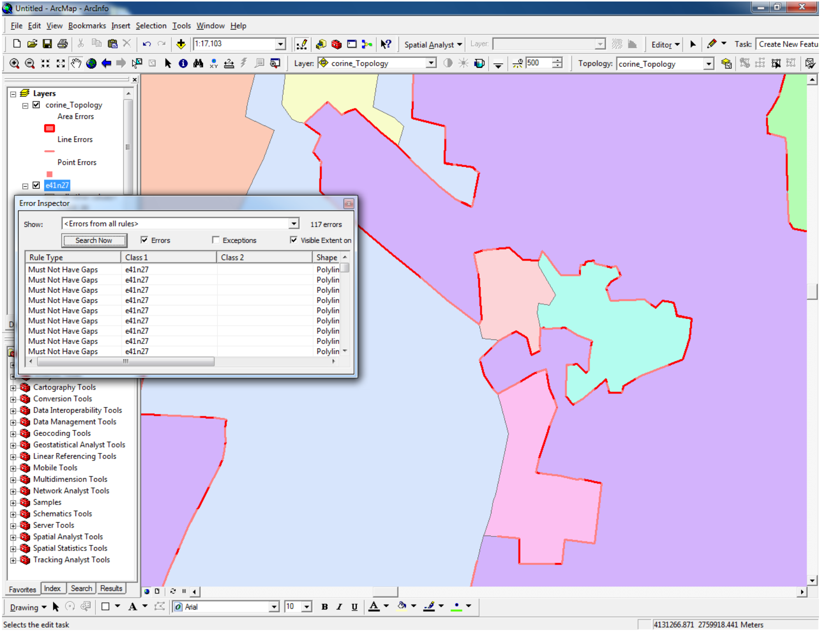
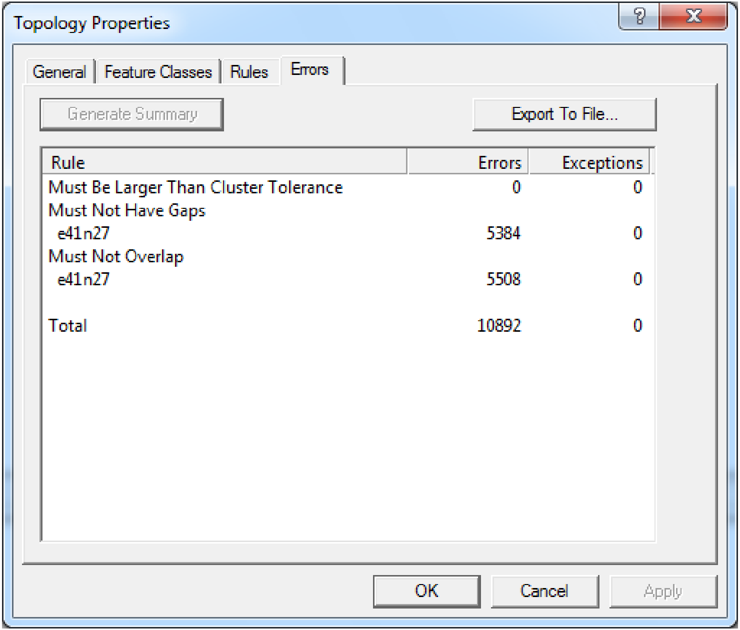


Topologically invalid result

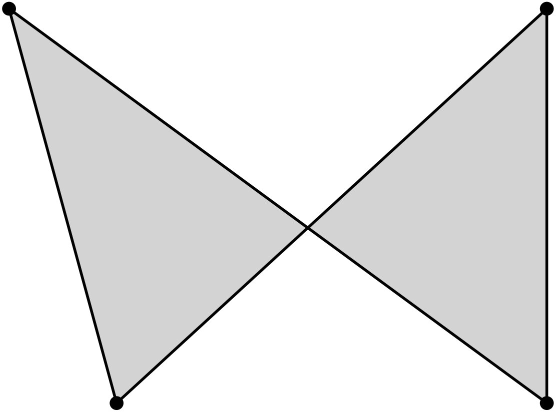
Topology rules



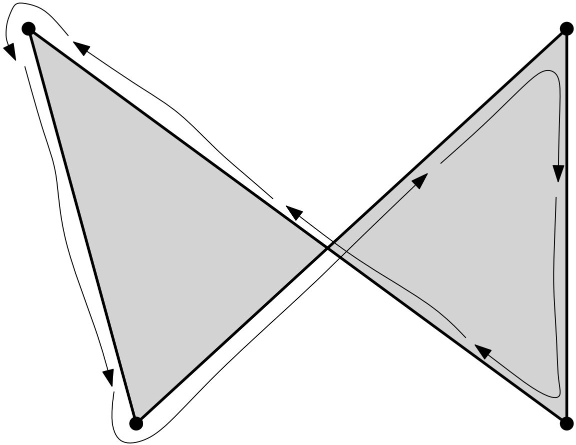
Manual work

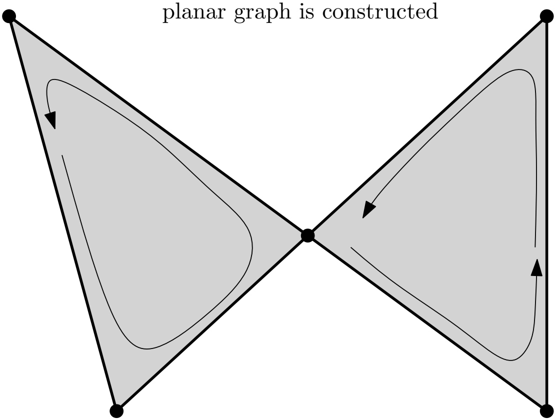

Topology Properties
General
Feature Classes
Rules
Errors
Generate Summary
Export To File...
Rule
Errors
Exceptions
Must Be Larger Than Cluster Tolerance 0 0
Must Not Have Gaps
e41n27 5384 0
Must Not Overlap
e41n27 5508 0
Total 10892 0
OK
Cancel
Apply

“Buffer-by-0”

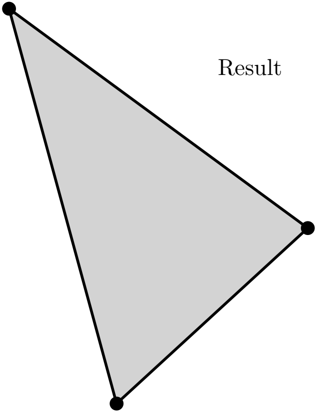


“Buffer-by-0”




planar graph is constructed

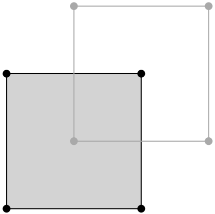
“Buffer-by-0”

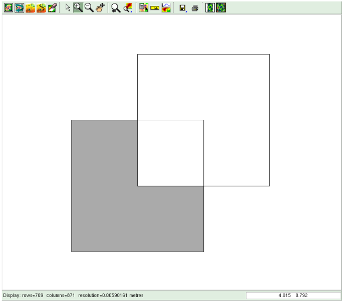


PostGIS 2.0's ST_MakeValid()

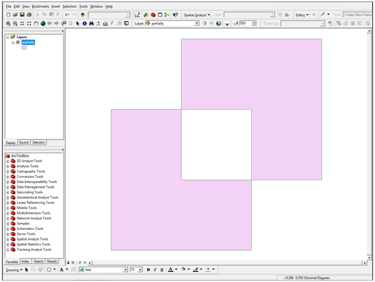
- high-level automatic repair function
- diff functions called depending on geometric and topological configurations of rings
- based on construction of planar graph (GEOS is used)
- not documented ("read the code") = predicting behaviour is difficult
- very slow for big polygons

“Visual repair”





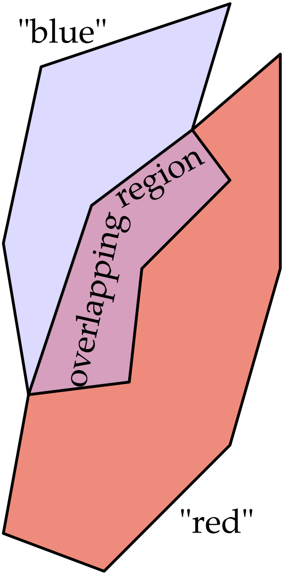
GRASS



ArcGIS

Our solution = constrained triangulation (CT)

1. Construct CT of input polygons
2. Flag each triangle with its polygon / interior & exterior
3. Make each triangle have *exactly* one tag
4. Reconstruct polygons



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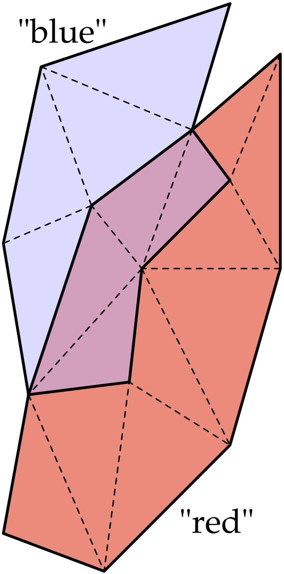

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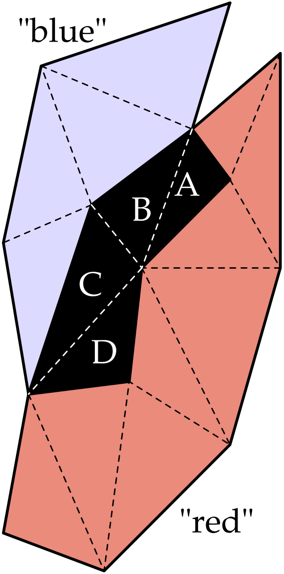

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Triangle	Repair
A	"red"
B	"red"
C	"red"
D	"red"

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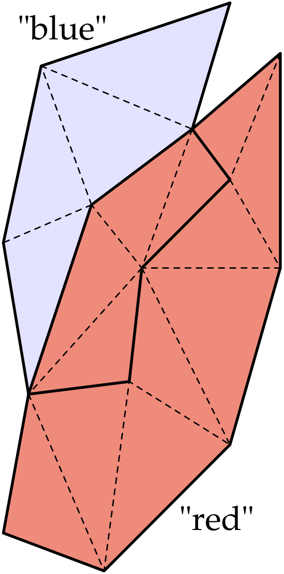

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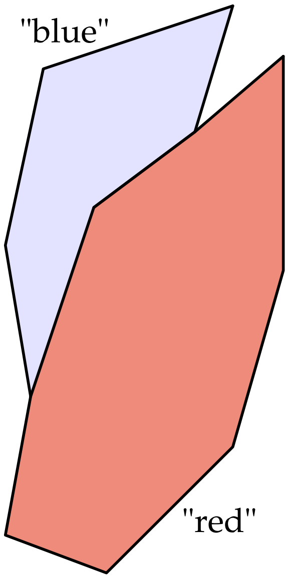
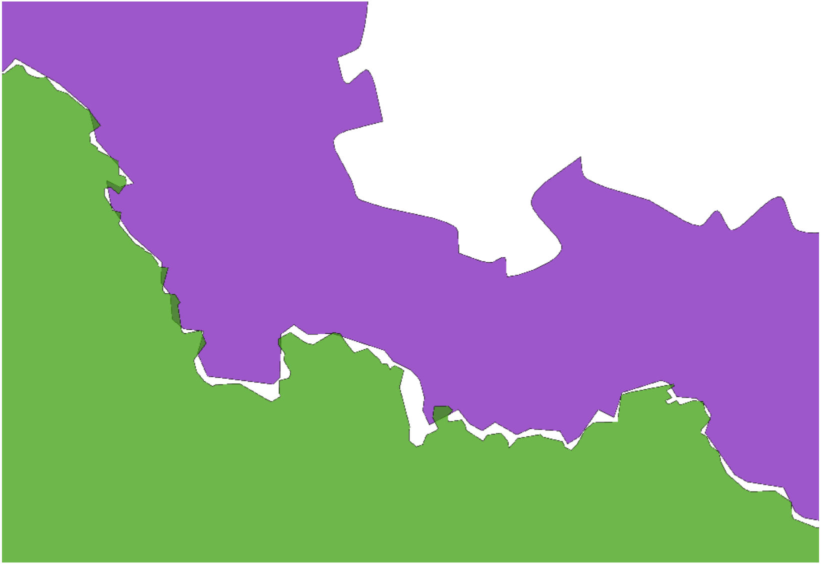


Local control: 6 different operators

Repair operation	Type	Criteria
Triangle by number of neighbours	Focal	The label present in the largest number of adjacent faces, overlaps included.
Triangle by absolute majority	Focal	Label present in two or more valid adjacent faces
Triangle by longest boundary	Focal	Label present along the longest portion of the boundary of the adjacent faces
Regions by longest boundary	Focal of zonal	Label present along the longest portion of the boundary of the adjacent faces
Regions by random neighbour	Focal of zonal	Random label from the adjacent faces
Triangle by priority list	Varies	Label that has the highest priority according to a predefined priority list

Local control: one concrete example



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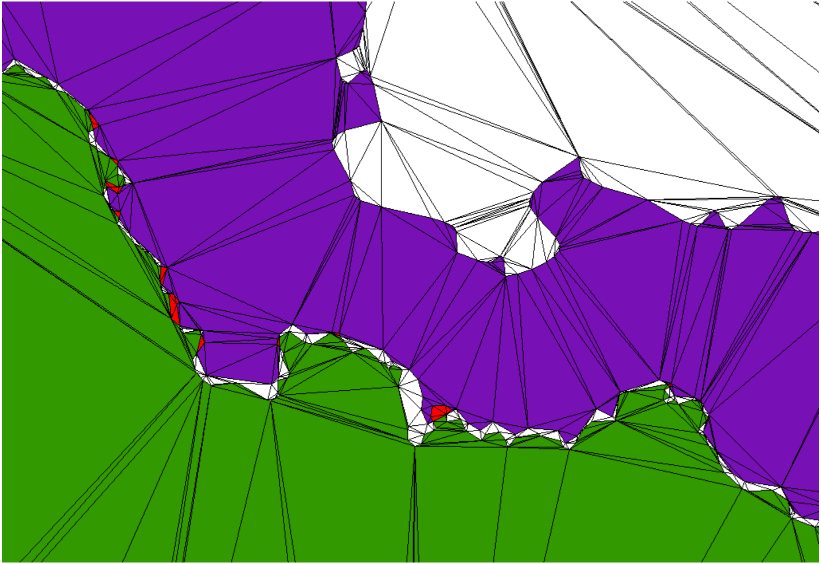

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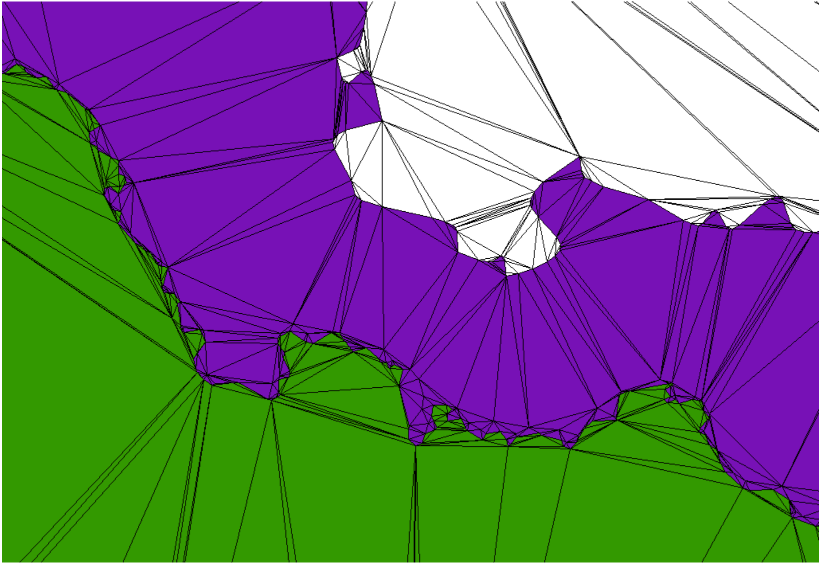

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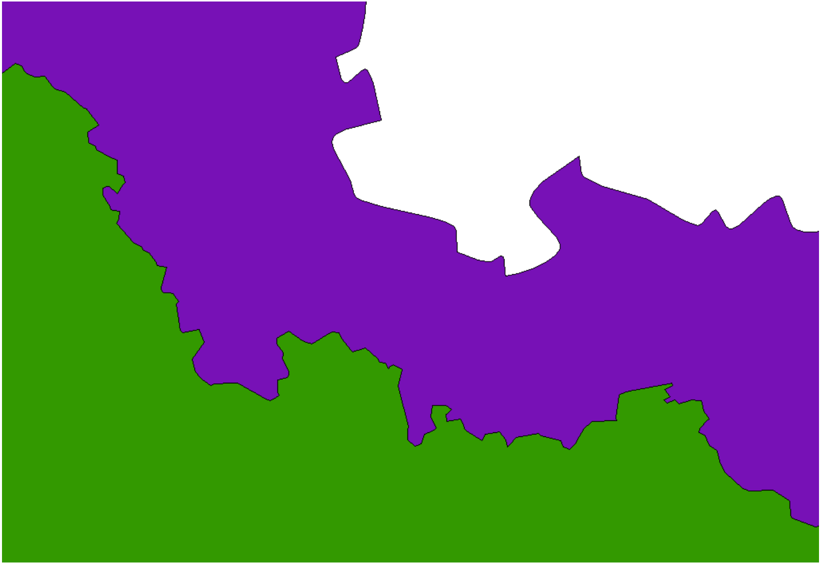
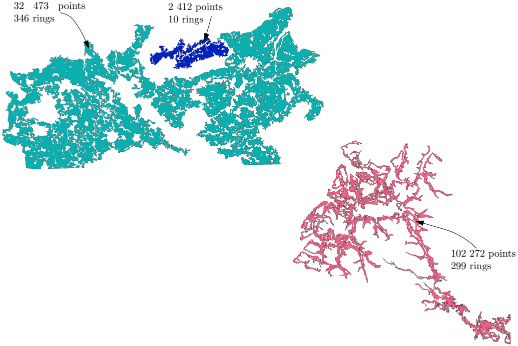


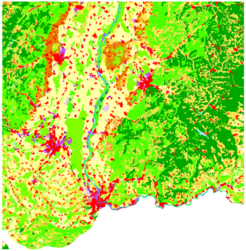
Local control: one concrete example

Experiments with big polygons: CORINE2006

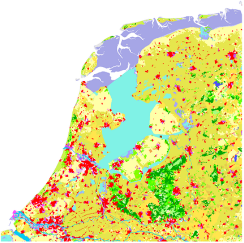


	points	rings	*prepair*	ST_MakeValid()
EU-47552	2 412	10	0.5s	0.8s
EU-47997	32 473	346	11.4s	314.0s
EU-180927	102 272	299	52.2s	740.2s

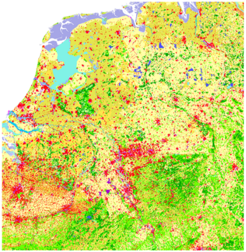
Experiments with large real-world datasets



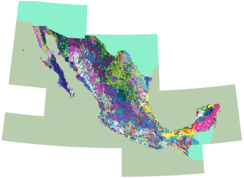
(a) E41N27



(b) 4tiles



(c) 16tiles



(d) Mexico

Experiments with large real-world datasets

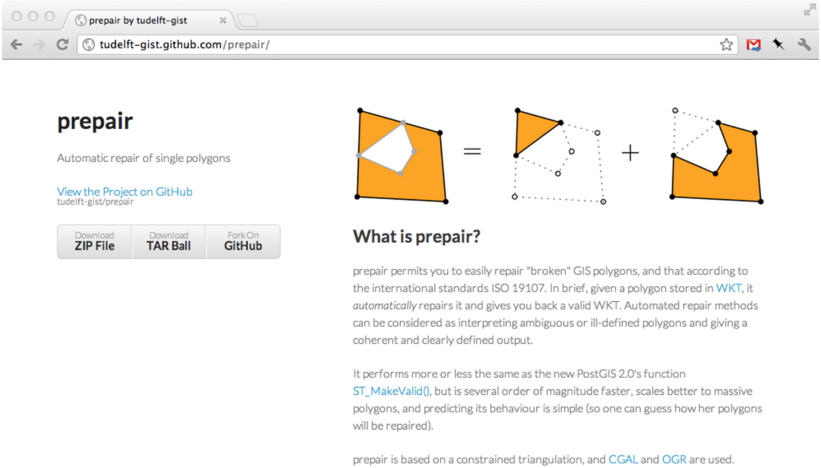
	# polygons	# pts	# pts largest polygon	avg # pts per polygon
E41N27	14 969	496 303	26 740	34
4tiles	4 984	365 702	16 961	75
16tiles	63 868	6 622 133	95 112	104
Mexico	26 866	4 181 354	117 736	156

Comparison with other GIS packages

	`pprepair`		ArcGIS		FME		GRASS	
	memory	time	memory	time	memory	time	memory	time
E41N27	145 MB	19s	145 MB	1m3s	158 MB	31s	59 MB	3m09s
4tiles	116 MB	17s	113 MB	37s	105 MB	31s	49 MB	53s
16tiles	1.45 GB	4m47s	crashes	–	636 MB	15m48s	crashes	–
Mexico	1.01 GB	3m31s	216 MB	$>$1d	264 MB	2m45s	408 MB	11m38s

The code is robust and freely available

- `http://tudelft-gist.github.com/pprepair`
- Uses OGR and CGAL
- BSD license → soon GPLv3



Thanks for your attention

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