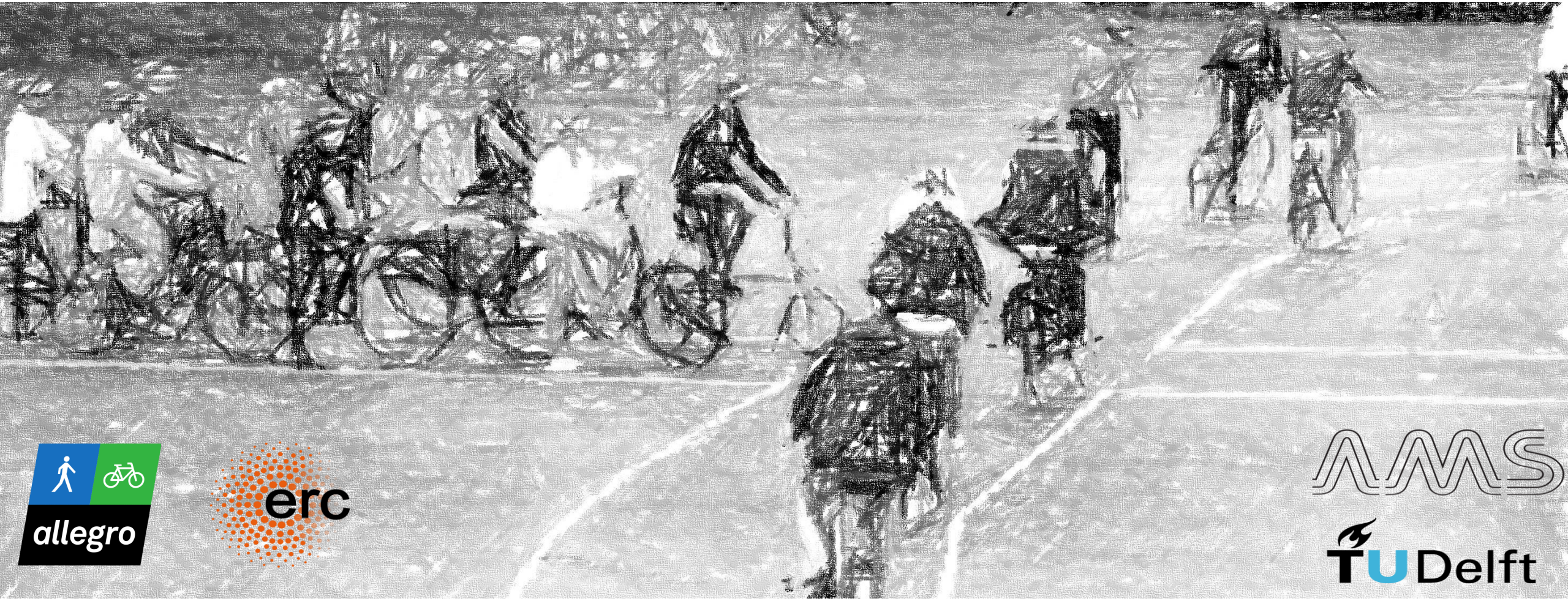
Voronoi densities for bicyclists: adaptation for finite object size and speed



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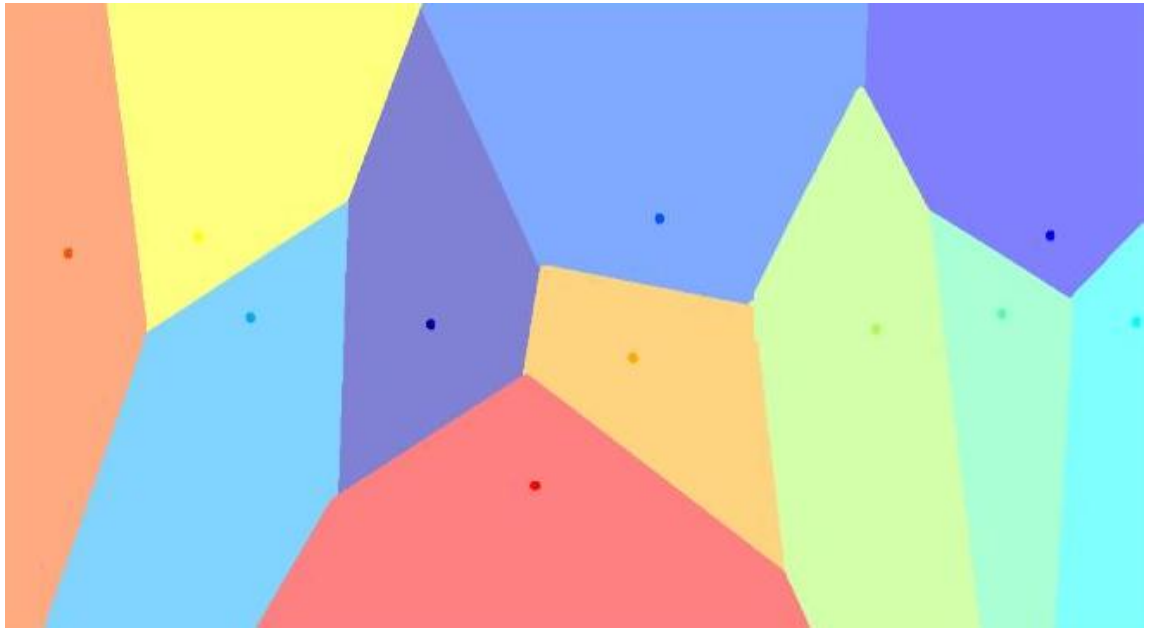
Voronoi method

- Voronoi-areas used to determine density
- Linking microscopic level to macroscopic level
- Allocation of space to individual cyclists
  - Simplify cyclist to points
  - Allocate space to the closest-by point



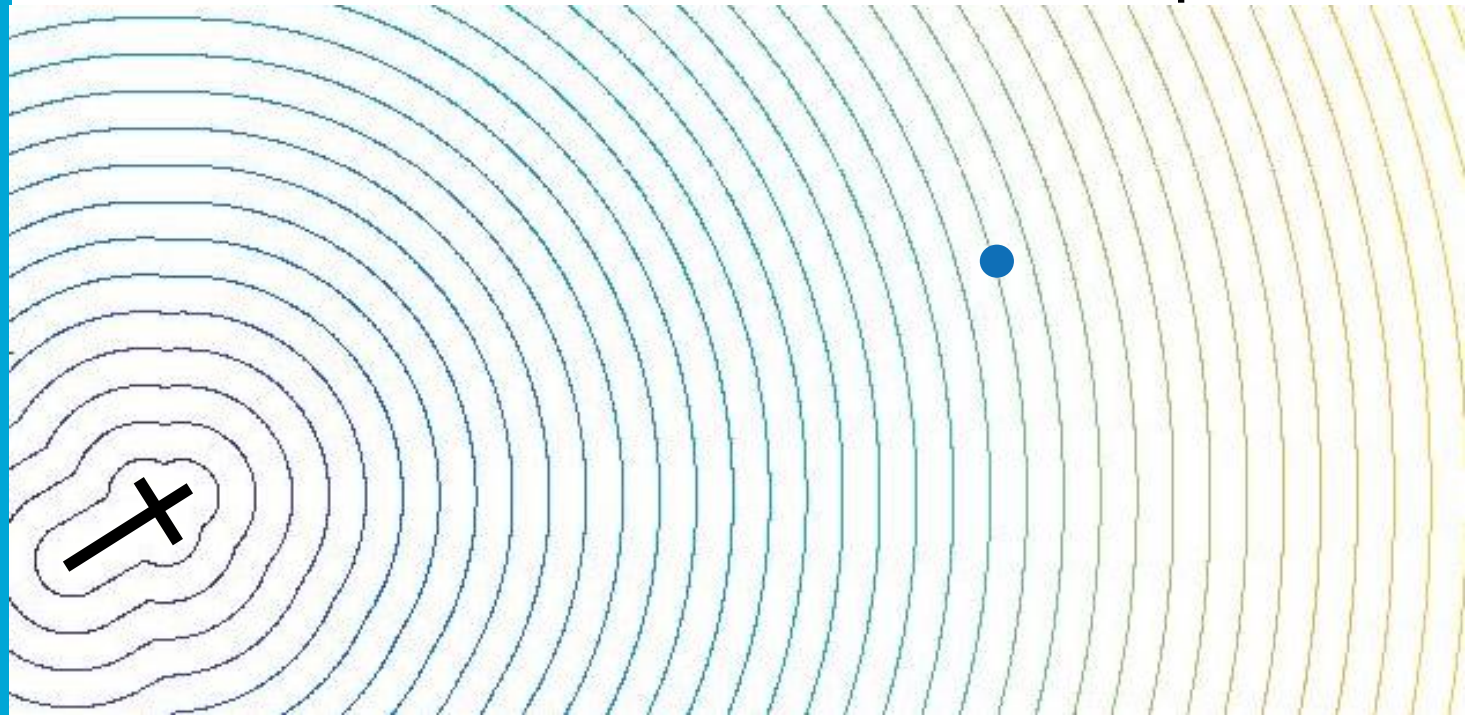
Contribution

- Issue: cyclists have a physical size and a speed that is non negligible

- Extend Voronoi method to consider:
  1. Size and non-circular shape of cyclists
  2. Anisotropy: space in cycling direction more important

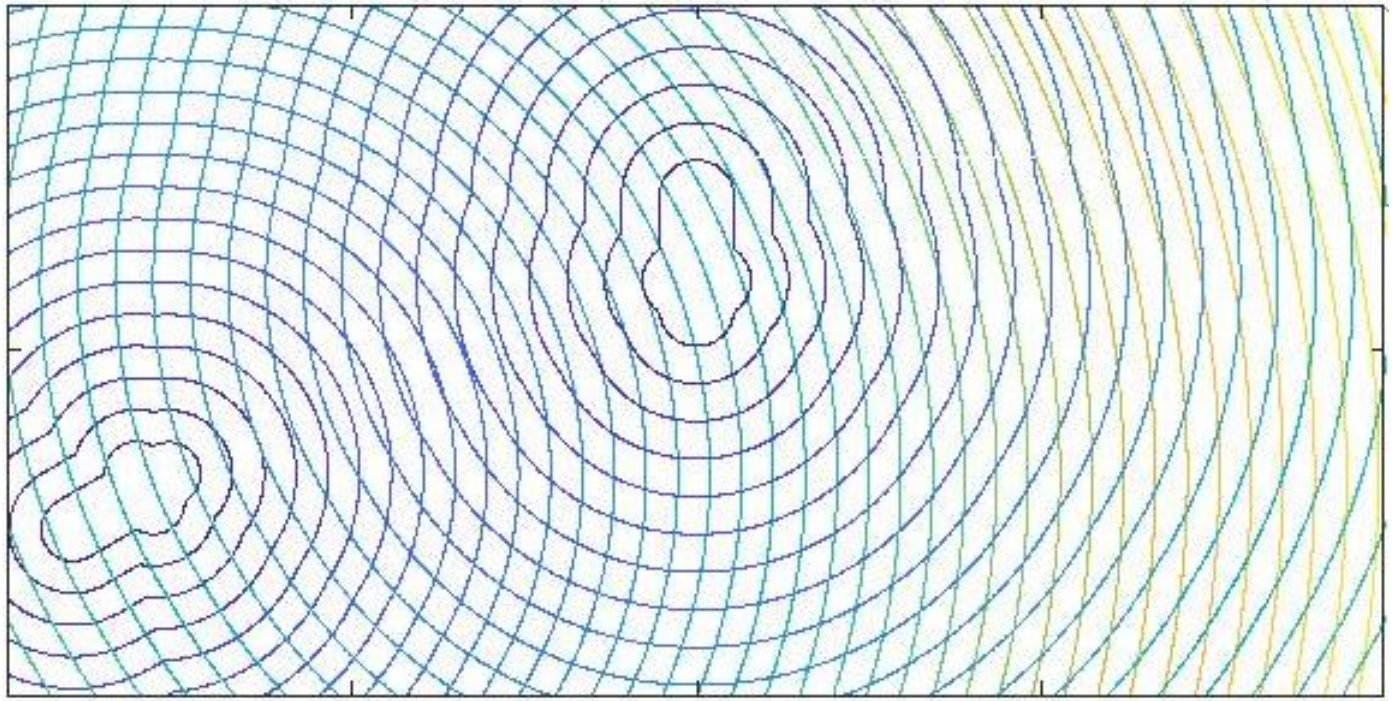
1. Adding physical size

- Model cyclists according to their shape and size
- Compute distance of one point in the area to all points of the modelled cyclist
- Take minimum distance, for all points in the area



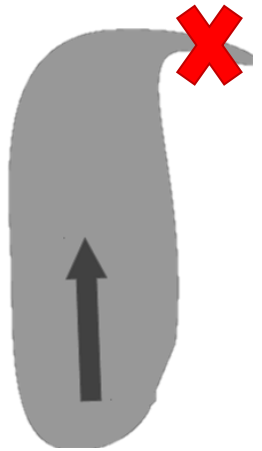
1. Adding physical size

- Multiple cyclists:
  - Allocate space to that cyclist for whom *any point* is closest

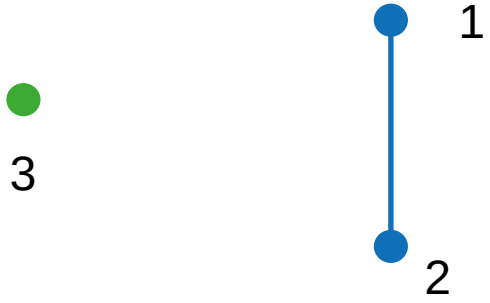


1. Adding physical size

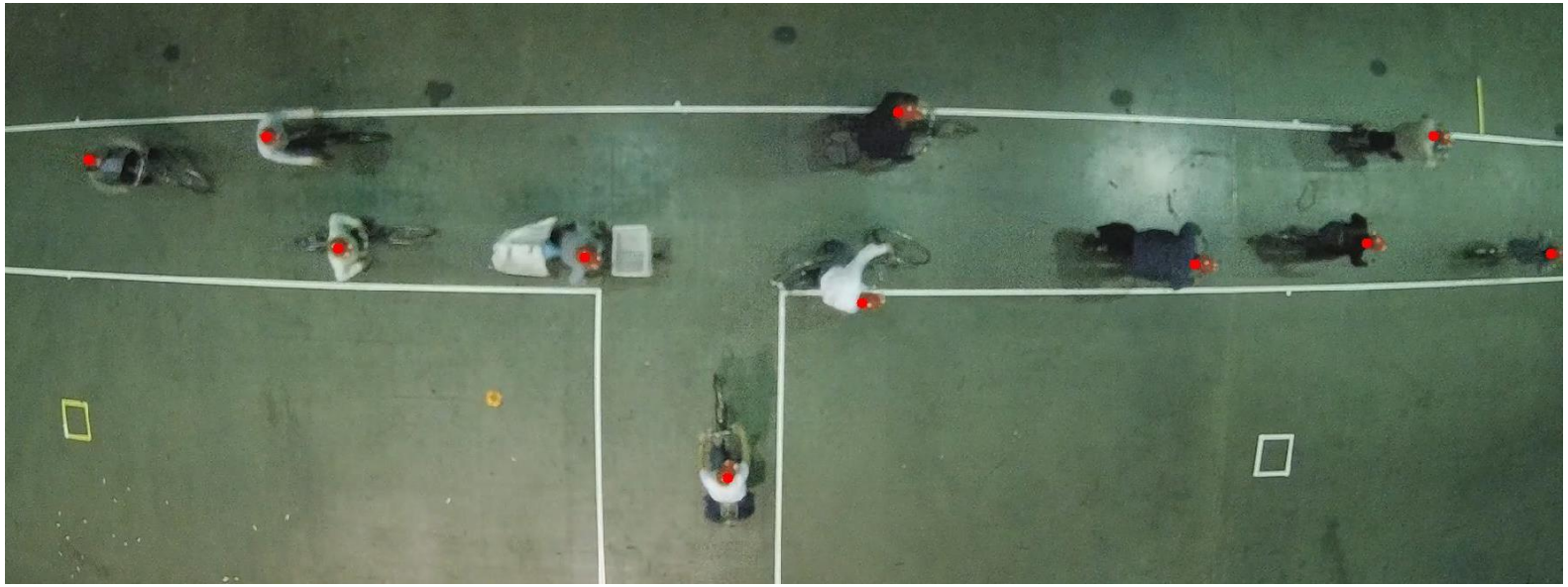
- Area for each cyclist is fully connected (no “islands”)

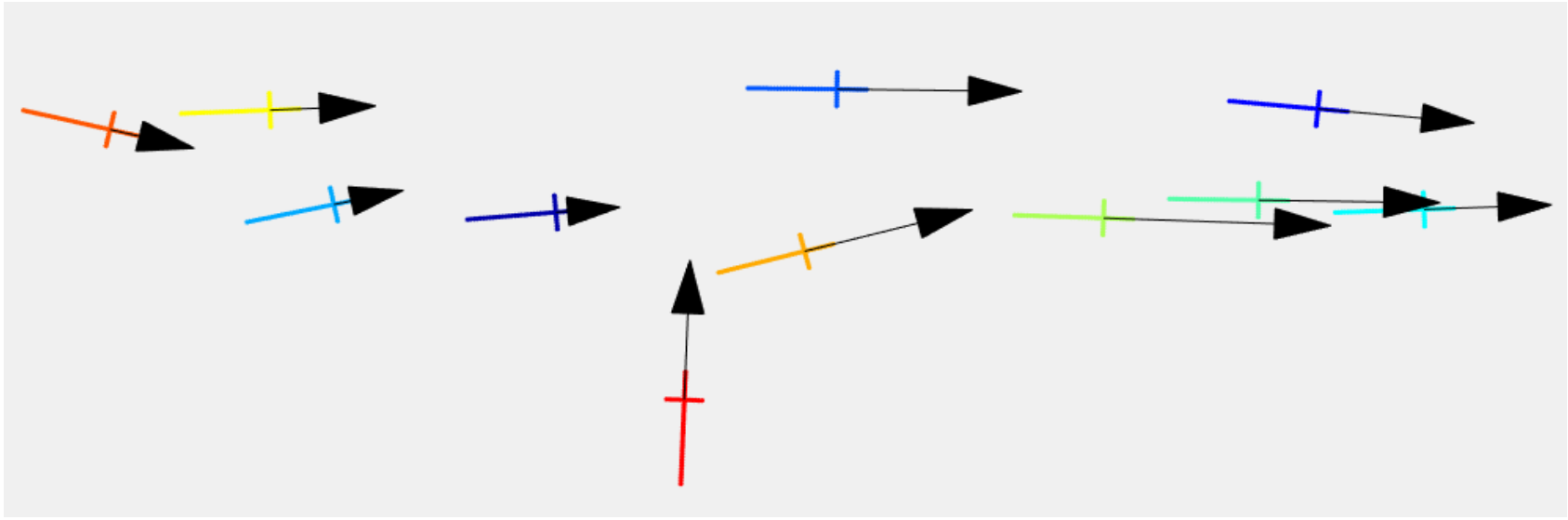


- Proof: triangle inequality
  - If area point 1 is closer to bicycle point 2 than to any other point, then that also holds for all points on that line



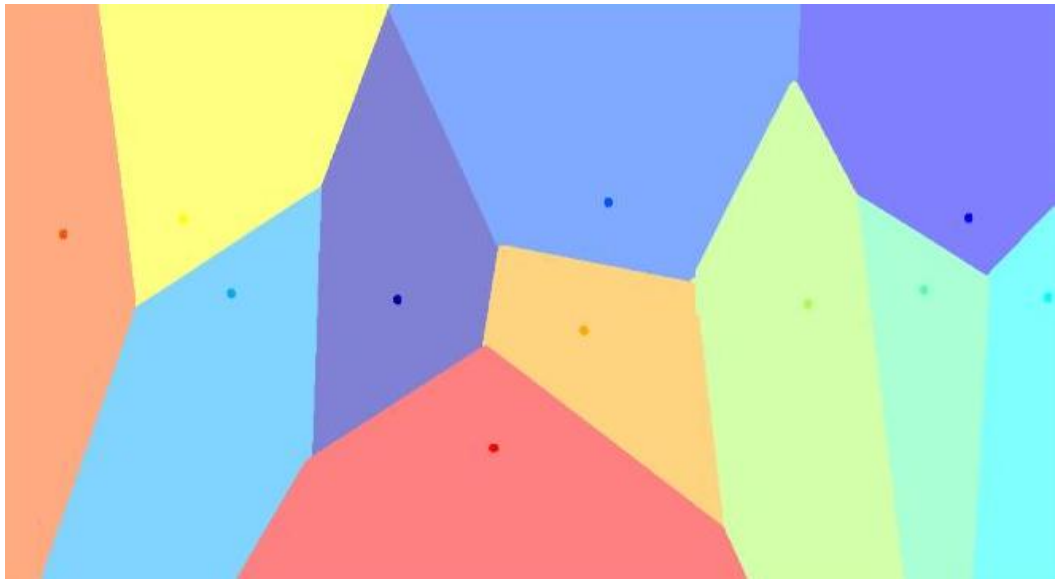
Data set used

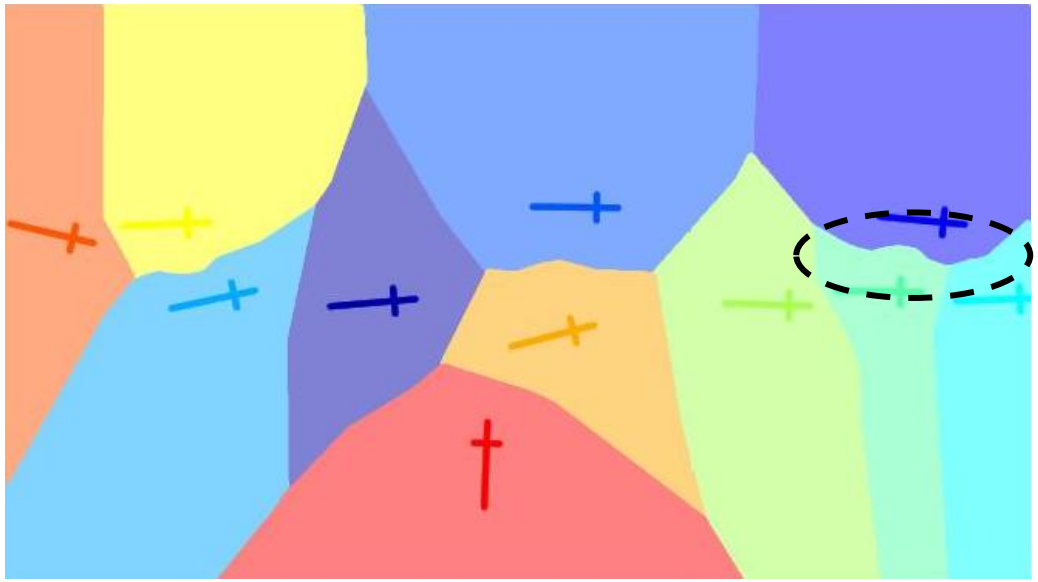




Resulting areas after adding size

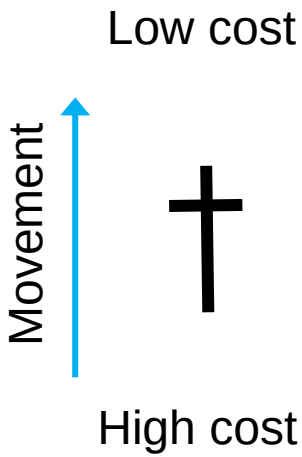
- Original
- Incl. size





2. Adding anisotropy/directionality

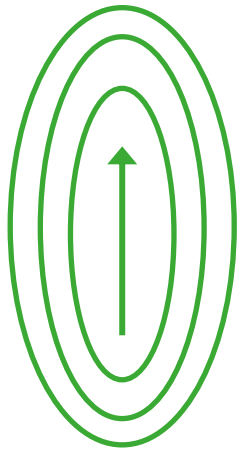
- Cyclists are more concerned about what happens in front than what happens behind
- This effect depends on their speed
- Introduce a “cost function”
- Cost represents a *perception* of distance to a certain point
- Cost ahead lower than cost behind
- Various functions are possible: define a cost as function of distance, speed, and angle.



Example anisotropy/directionality

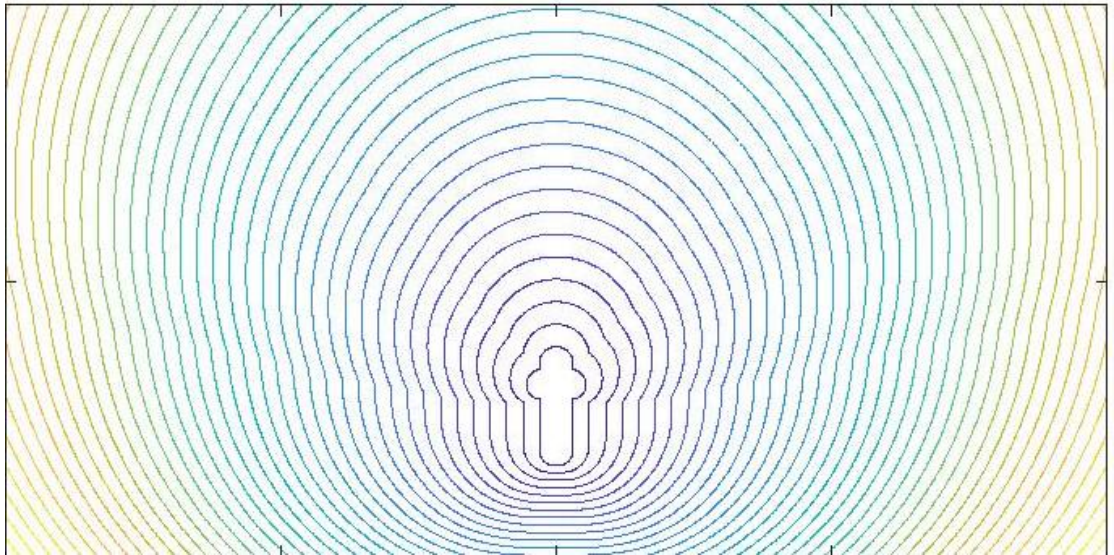
Iso-cost lines in **ellipses**:

- Circles with 2 midpoints:
  1) Bicycle
  2) Moved point based on speed
- Same cost increase front and rear



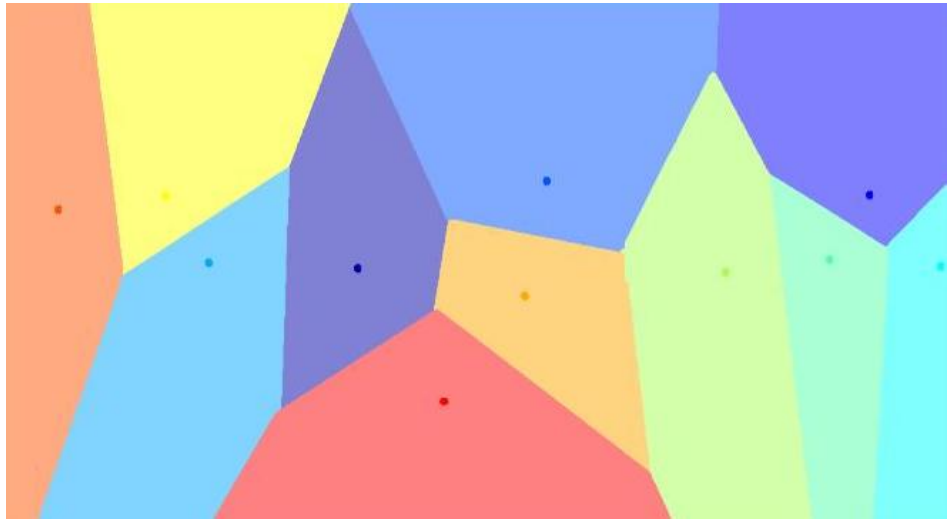
Alternative cost function:

- $C = \frac{R}{\alpha - \cos\theta}$
  - R: Euclidian distance
  - α: parameter for front-rear anisotropy (dependent on speed)
  - θ: angle

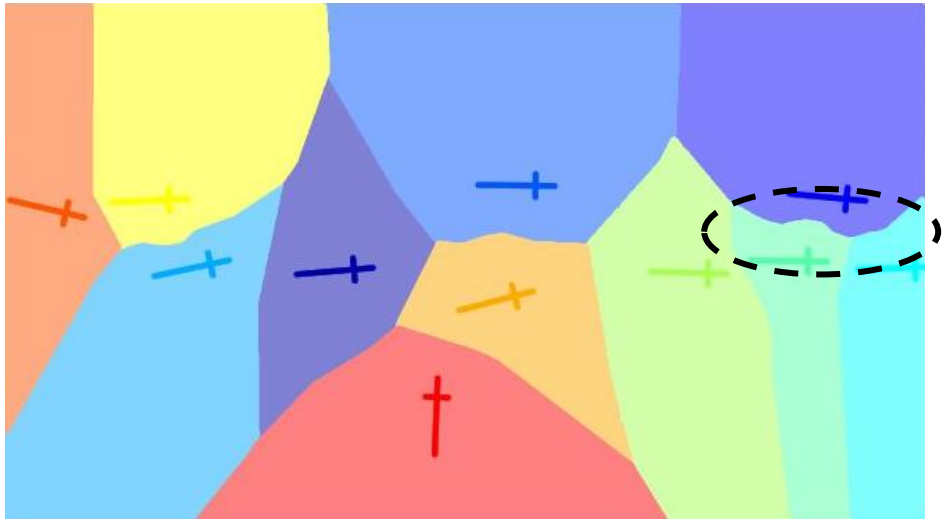


Resulting Voronoi areas

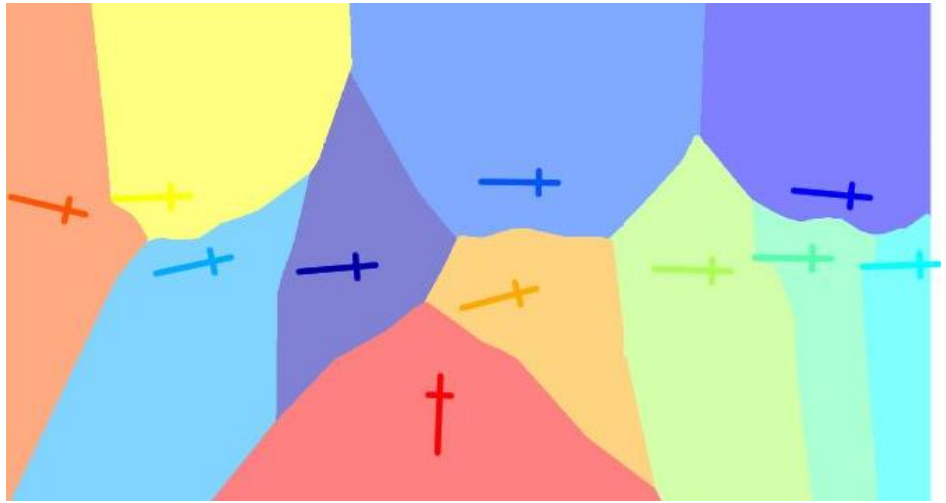
Original



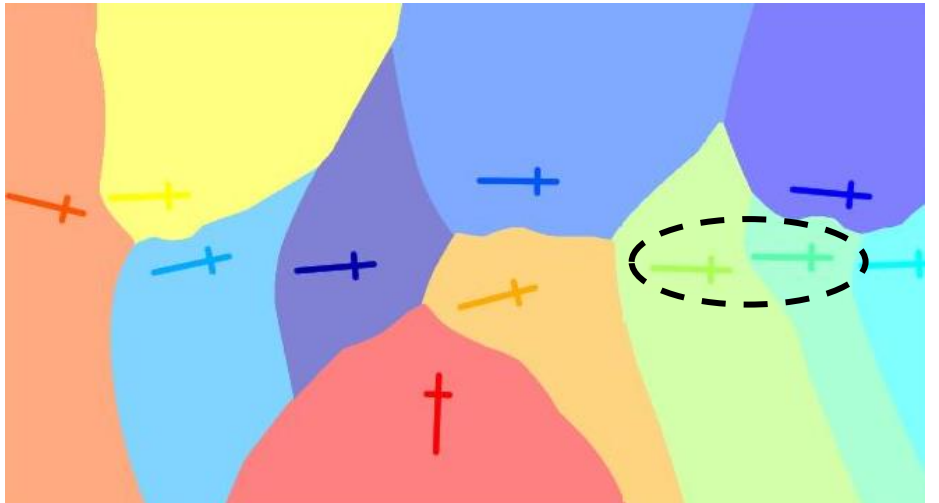
Incl. size



Incl. size & anisotropy (elliptical)

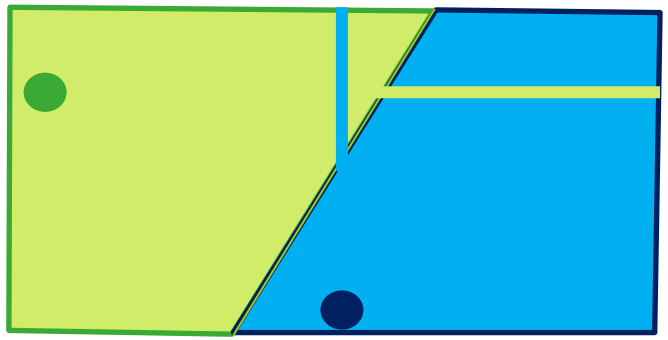


Incl. size & anisotropy (alternative)



Follow-up work

- It is possible with angle-dependent cost functions that the area allocated to a cyclist is interrupted by another cyclist, e.g. if going straight is cheap:



- Change this to another computational method such that the area can only be extended in line with area available for that cyclist

Wrap-up

- Introducing a voronoi-based method
  - taking into account the physical size of cyclists
  - exploring speed and angle specific functions to express heterogeneity
- Next steps
  - explore more functions
  - investigate effect on fundamental diagram