

Visualizing Mixing of Vortex Patches

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April 11, 2017

1 AIM

To determine the movement of two identical vortex patches estimated as 2 groups of blobs in free space.

2 Code working

A Set of Blobs can be estimated as vortex patch, though this is fairly arbitrary it is theoretically a good approximation for computations involving vortex patches.

In this Computation we shall do the following

- Define a Blob Class that contains all the required parameters.
- Take inputs of No.of blobs in each patch, time interval per iterations, no.of iterations, distance between the two centre of masses of the patches, strength of each blob and radius of each blob
- Distribute centres of the N blobs both uniformly and randomly whichever is required, centered around two points at some distance d.
- Draw the intial distribution
- Now compute the velocity induced by each vortex blob on another and displace each blob by vdt , dt being the time interval of the computation.
- Draw the new distribution as and when required (once every 1 sec in this simulation)
- Draw the final distribution after c iterations

3 Observations

3.1 $d=100$, $N=100$ blobs/patch, $c=100$ iterations

By 100 iterations we see the patches are starting to mix

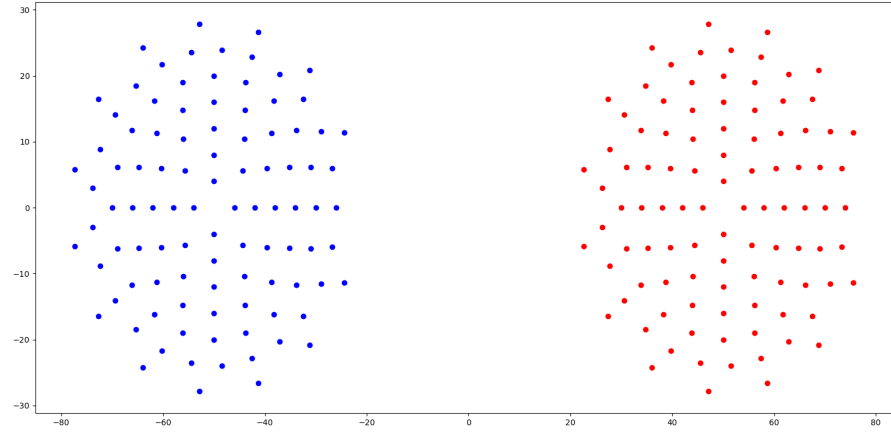


Figure 1: Initial positions for 3.1

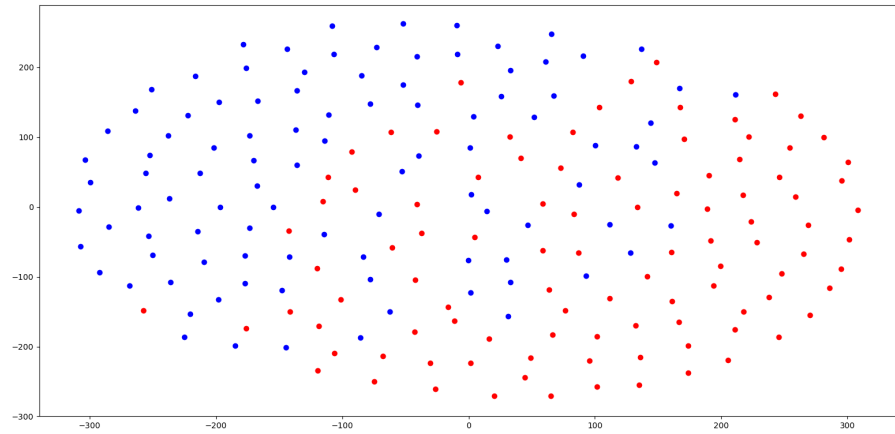


Figure 2: Final positions for 3.1

3.2 $d=300$, $N=100$ blobs/patch, $c=100$ iterations

They start to mix by 30 iterations but dont finish mixing completely even after 100 as we see trailing blobs and also they only start to come closes and very little mixing actually takes place

Upon running the simulation for longer periods we see there is a good amount of mixing after 700 iterations

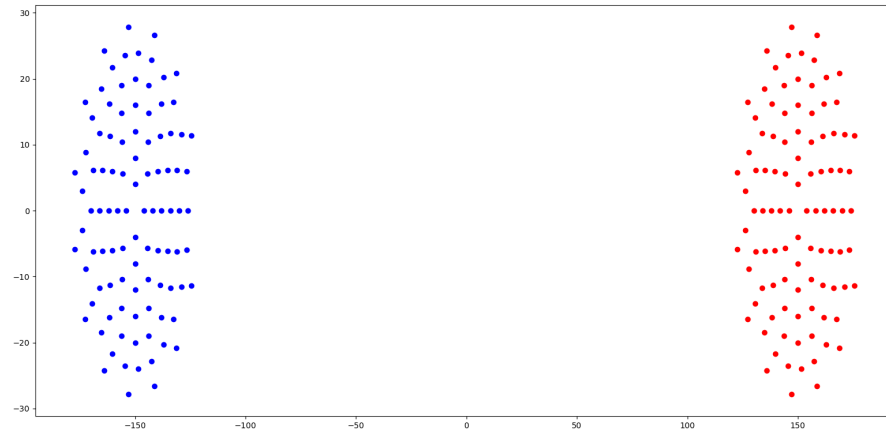


Figure 3: Initial positions for 3.2

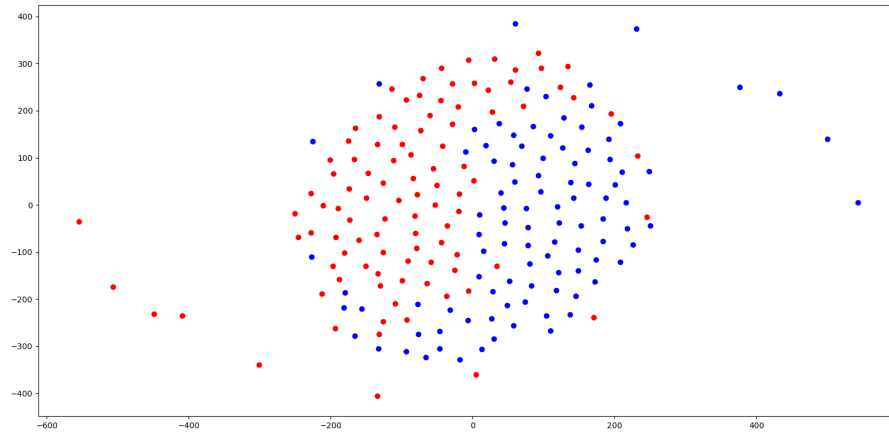


Figure 4: Final positions for 3.2

3.3 $d=500$, $N=100\text{blobs/patch}$, $c=300$ iterations

We see from the plots that this is an exaggerated case of the above even after simulating for 30secs

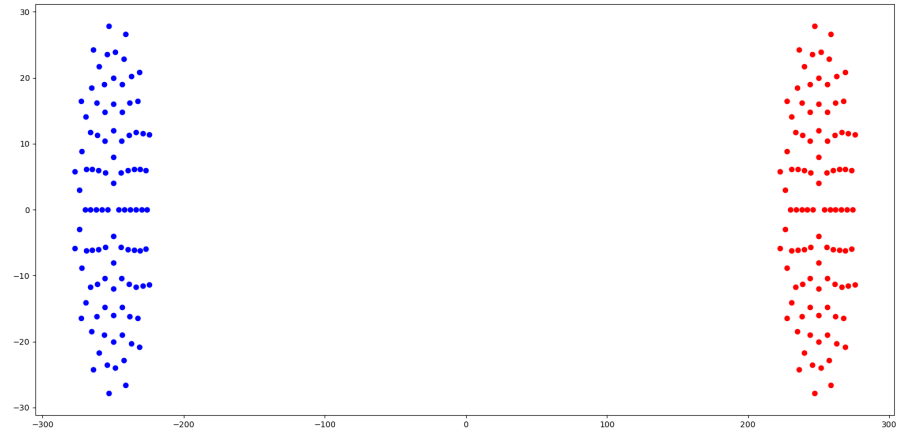


Figure 5: Initial positions for 3.3

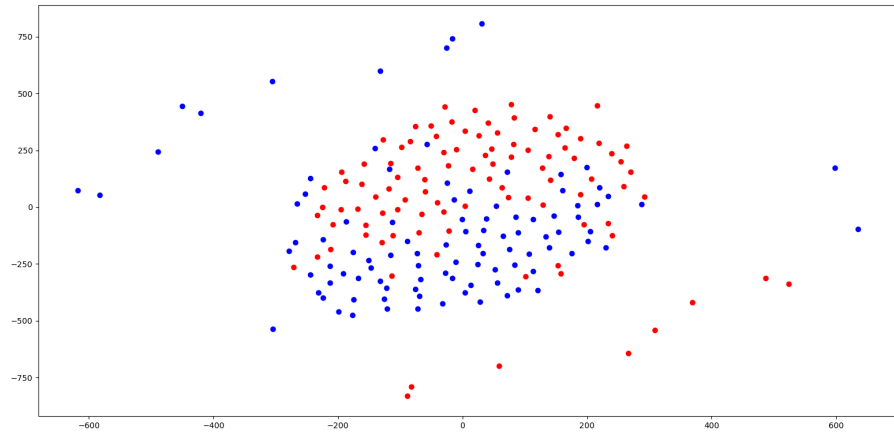


Figure 6: Final positions for 3.3

3.4 $d=1000$, $N=100\text{blobs/patch}$, $c=500$ iterations

Even after 500 iterations i.e 50 seconds the patches don't even come close to mixing

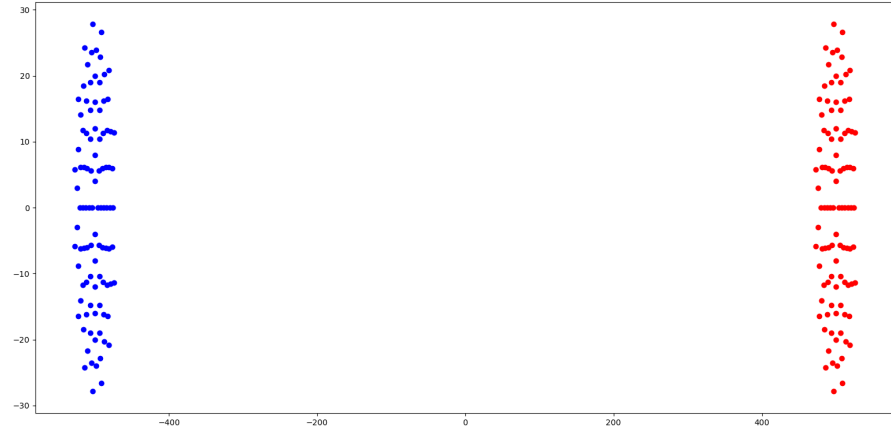


Figure 7: Initial positions for 3.4

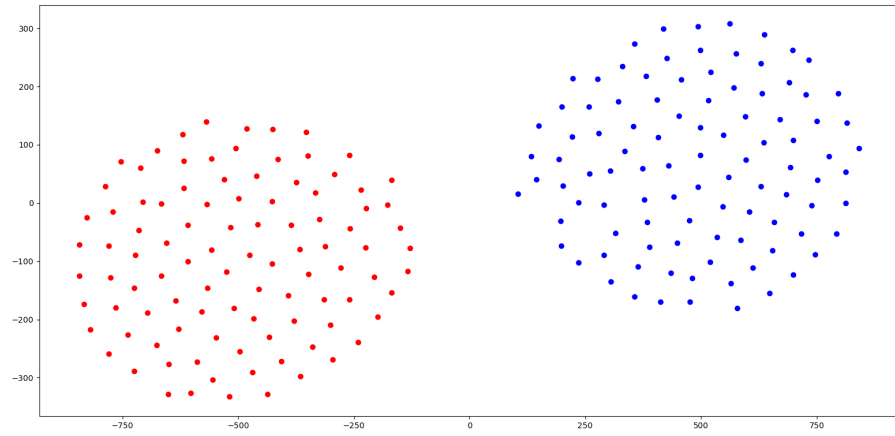


Figure 8: Final positions for 3.4

3.5 $d=1000$, $N=10$ blobs/patch, $c=20000$ iterations

For 10 blobs at the same distance we see nothing happens after 500 seconds though mixing starts after about 2000secs, from this we can say no matter at what distance the two patches are initially, for any finite distance there exists some finite time after which the two patches start mixing

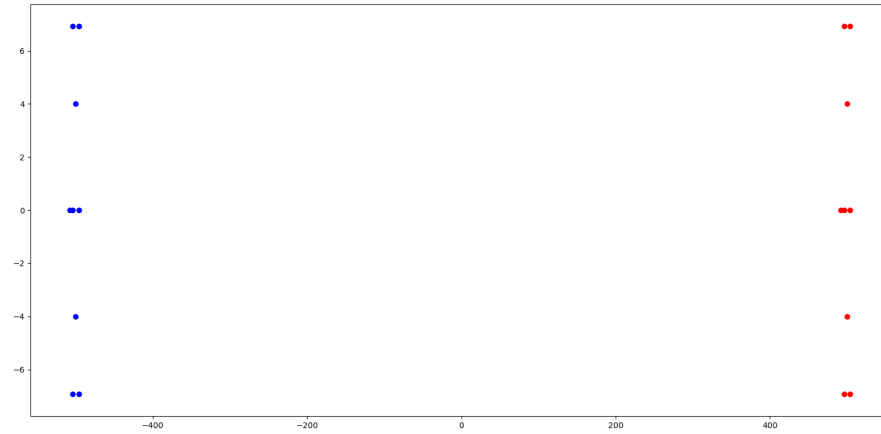


Figure 9: Initial positions for 3.5

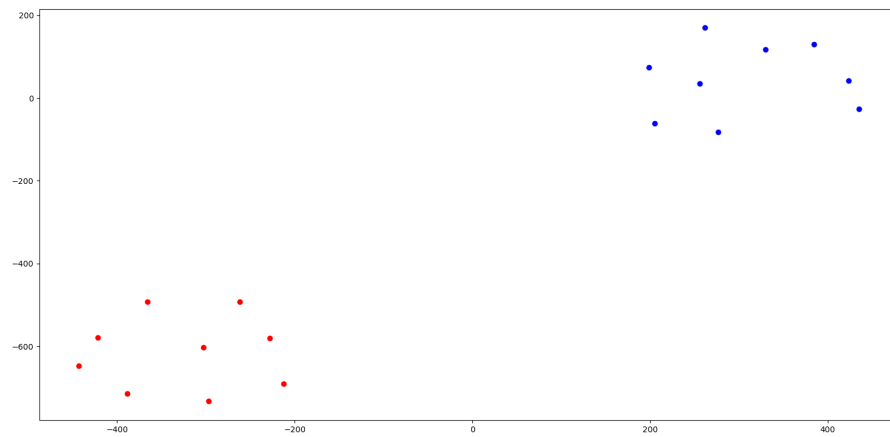


Figure 10: positions for 3.5 after 500secs

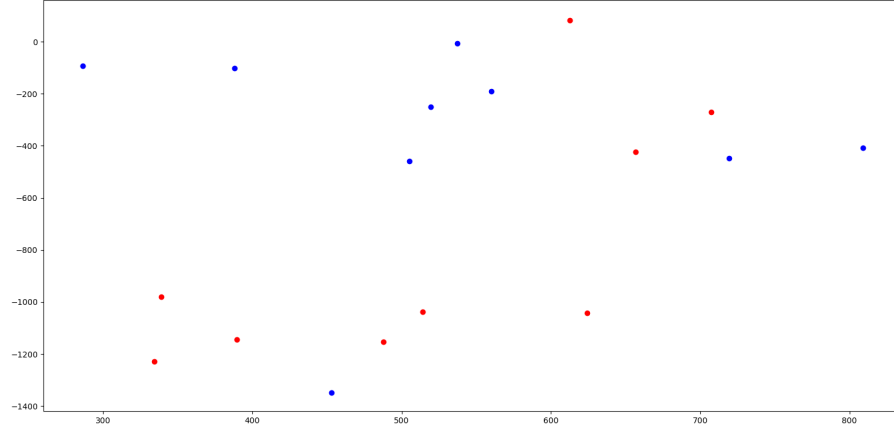


Figure 11: Final positions for 3.5 after 2000secs

3.6 $d=100$, $N=100$ blobs/patch, $c=100$ iterations, patches have same magnitude but of opposite sense

In this case we see that pairs of blobs from different patches start pushing each other in straight lines and slowly diverge out

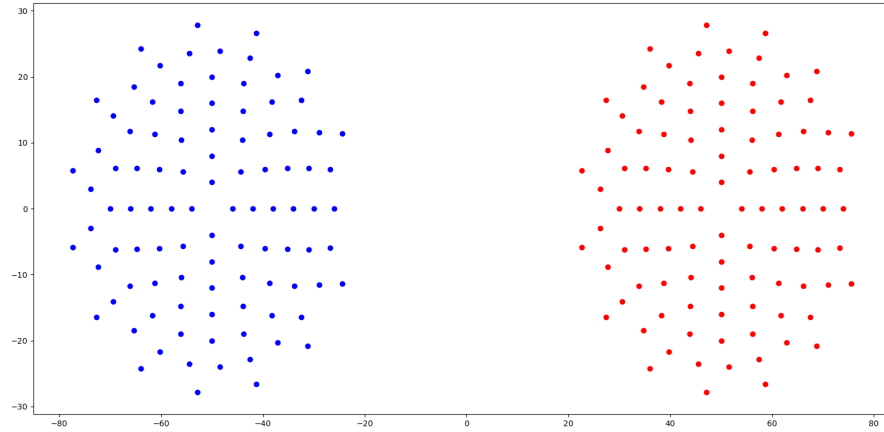


Figure 12: Initial positions for 3.6

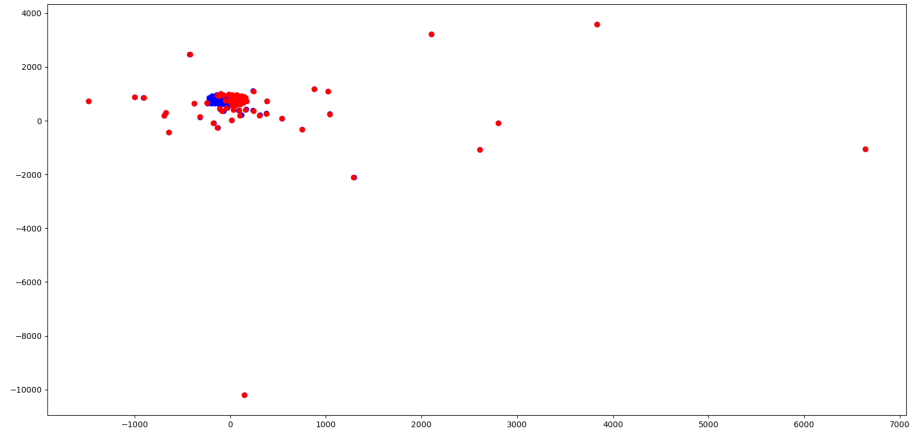


Figure 13: Final positions for 3.6

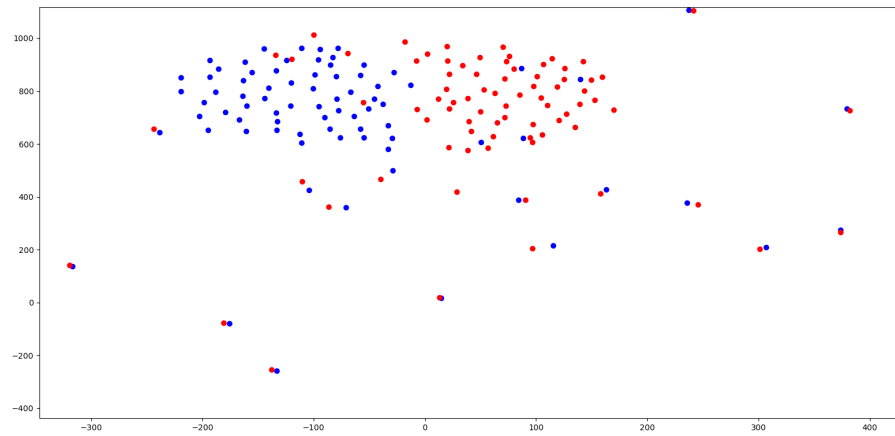


Figure 14: Final close up positions for 3.6

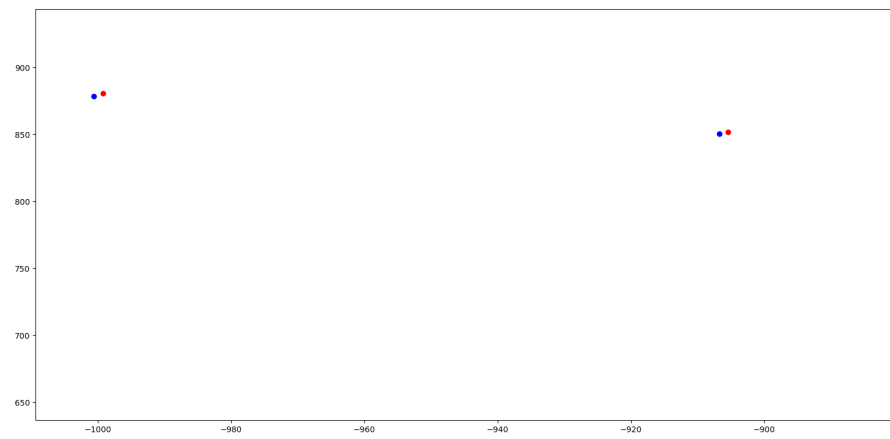


Figure 15: Final positions for 3.6 - pairs of vortex blobs