# Lagrangian Coherent Track Initialisation

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**Abstract**

A coherency-based algorithm to build new tracks from local Lagrangian information of particles is introduced. In Lagrangian Coherent Track Initialisation (LCTI), we mainly concentrated on how to initialise first four-time steps, new entries and lost tracks, by a physics-based iterative forward-backwards four frame technique as a complementary function of Kernelized Lagrangian Particle Tracking (KLPT) [1] and Shake The Box (STB) [2]. Methods like as KLPT and STB require initial tracks to start predicting and optimising trajectories. More accurate initialisation technique could prevent the algorithm from failing or improve the convergence speed. Moreover, particles are continuously entering into the domain, which means, no matter how effective the algorithm can track a specific number of particles, new trajectories must be fed into the tracked pool. Otherwise, all tracked particles would leave the domain and at some point, there would be no new tracks. In the case of having complex flow motion, some particles lose their trajectories at the end of each time step. It is vital to return those lost particles into the tracked pool since an increasing number of lost tracks will increase the chance of being ignored by the algorithm as ghost or noise. The idea is that new entry and lost particles follow the same behaviour of their surrounding neighbours which means a new track is built if the trajectory is coherent with other neighbour tracks.

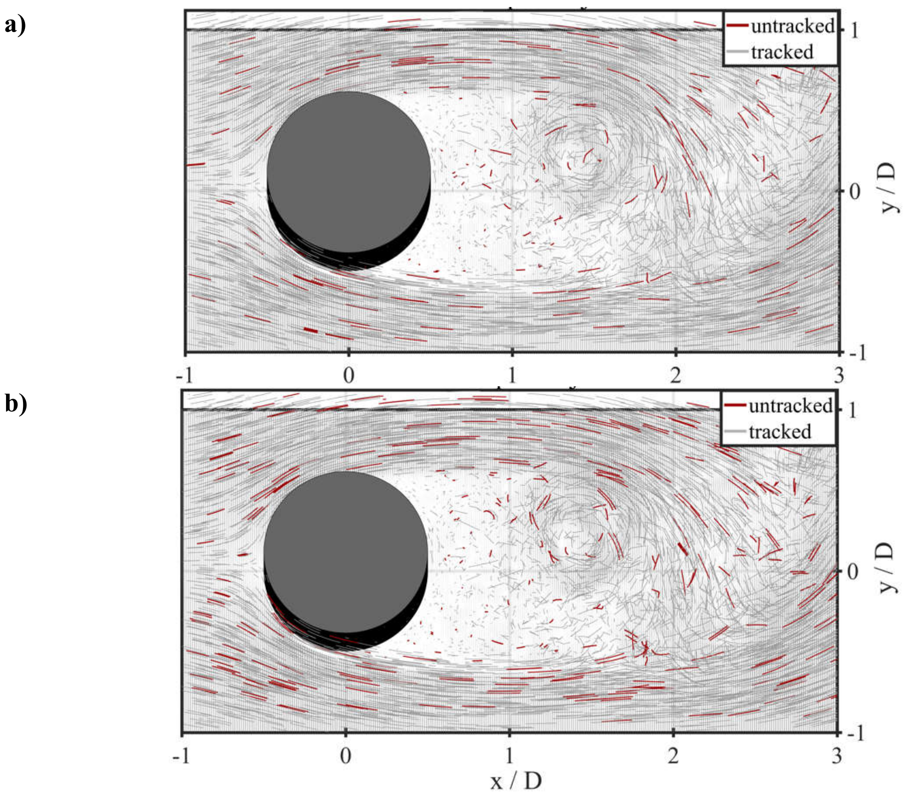


**Fig. 1** Top view of 3D flow behind a cylinder, True track detection comparison between **a)** using Lagrangian Coherent Track Initialisation (LCTI) and **b)** Enhanced Track Initialisation (ETI), red lines are trajectories either untracked or mistracked, and grey lines are true tracks. Eulerian vector field is in the background.

Four frame track initialisations methods have been recently developed such as Enhanced Track Initialisation (4BE-ETI [3]) by looking for all track possibilities or four-frame best estimate (4BE) [4] by looking for nearest neighbours in frames until a unique track is found. The current coherency-based initialisation technique is following the same four frame approach but tries to find a coherent solution instead unique solution. Coherent refers to a group of particles which are spatially and temporally having same Lagrangian behaviour. This requires a function to determine information of coherent and non-coherent locally. There are many available concepts to identify Lagrangian Coherent Structures (LCS) [5] from estimating separatrix lines or surfaces which divide structures into different coherent regions. In Lagrangian frames, separatrices can be achieved from a scalar value called Finite-Time Lyapunov Exponent (FTLE) [5] by measuring the amount of stretching between the target particle and its neighbour particles over the time [6]. If a possible track is coherent with nearest tracks, then it will be indexed into track pool. This process continues iteratively until no track is found to be coherent with track pool.

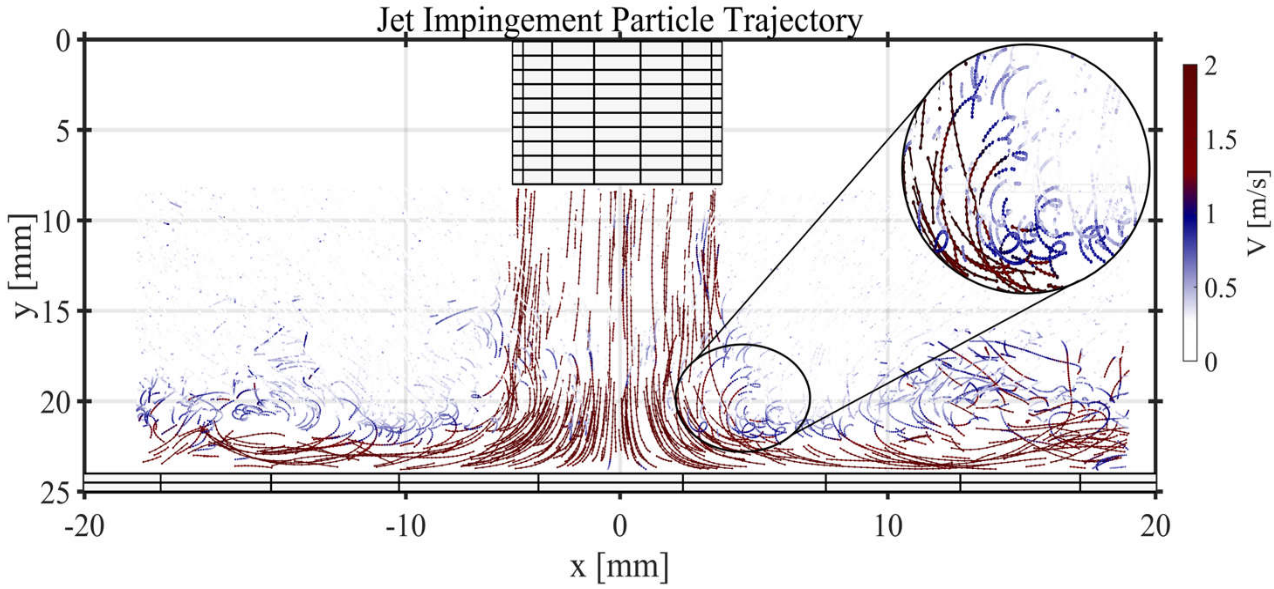


**Fig. 2** Side view of particle trajectories colored by velocity magnitude in Jet Impingement at 0.03 ppp, low-velocity tracks away from the jet core are filtered for clear qualitative view thanks to the colorbar.

LCTI was tested using synthetic data over a cylinder obtained from 3D direct numerical simulation (DNS) at Reynolds number of 3900 and experimental jet impingement flow at Reynolds number of 2500. Both ETI and LCTI were computed in long tracks for the sake of qualitative visualisation although they are four frames. Figure 1 shows improvements compared to ETI at 0.05 ppp in a slice of 4D*2D*2D. High level of shear and velocity gradients exist in both sides of the vortex formation region in which LCTI has over 10 per cent more true tracks. Meanwhile, there is higher accuracy in track detection where the vortices are formed. Figure 2 also shows particle trajectories when a high accelerated jet impinges into a solid. The proposed method is able to follow complex motions such as vortex rings around the jet that their signatures can be seen from particle motions.

## References

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