A close up of a logo

Description automatically generated A close up of a sign

Description automatically generated 

IMAGE PROCESSING AND DUST TRAJECTORY TRACKING IN TOKOMAKS

**By**

Arpan KHANDELWAL

**Tutor for Internship**

Didier VEZINET

**Tutor for IMT Atlantique**

Amanda PORTA

**Enterprise**

CEA Cadarache/IRFM

SUMMARY

From 25th February to 30th August 2019, I have done my internship at the Institute for Magnetic fusion research (**Institut de Recherche sur la Fusion par confinement Magnétique, IRFM**).

IRFM is one of the 15 institutes that make up the fundamental research division in CEA (Direction de la Recherche Fondamentale). For almost 60 years, its responsibility has been to carry out research on thermonuclear magnetically confined fusion at the CEA in association with the Euratom Fusion Programme. Since the beginning of the Tore Supra programme in the late 80s, it has been located at the CEA Research Centre of Cadarache in the department of the Bouches-du-Rhône. To fulfil its missions, IRFM gathers three departments (and within them, groups), with various objectives expanding from engineering to physics to platform operation.

The IRFM activities are structured around three main areas:

- Contribute to the implementation of the ITER project and those of the “Broader Approach”,

- Prepare the scientific operation of ITER, through control and experimentation activities, and through theory and modelling,

- Establish the basis for future fusion reactor.

Those activities are closely linked to a special effort in education for the new physicist and engineers in fusion sciences.The IRFM is equipped with several R&D platforms, the best known is the Tore Supra tokamak which is becoming WEST (W – tungsten Environment Steady-state Tokamak) to test the ITER divertor.

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas:

* defence and security,
* low carbon energies (nuclear and renewable energies),
* technological research for industry,
* fundamental research in the physical sciences and life sciences.

Drawing on its widely acknowledged expertise, the CEA actively participates in collaborative projects with many academic and industrial partners. The CEA is established in nine centres spread throughout France. It works in partnership with many other research bodies, local authorities and universities. Within this context, the CEA is a stakeholder in a series of national alliances set up to coordinate French research in energy (ANCRE), life sciences and health (AVIESAN), digital science and technology (ALLISTENE), environmental sciences (AllEnvi) and human and social sciences (ATHENA).

To perform dust detection on movies, I must separate them from the rest of the movies. Since dust particles are light emitting particles and they are brighter than other objects present such as the plasma, the vacuum vessel wall. After their separation, the dust particles on all the frames need to be associated with each other. After the association we can track their trajectories and thus gather information such as dust velocity, distribution etc.

Hence this task can be divided into four parts:

1. Pre-processing: This involves removing all unnecessary information to reveal the dust particles. The associated steps involve grayscale conversion, denoising, smoothing, binary conversion. After this step only dust particles are left in the images.
2. Dust detection: This step involves detecting the dust particles present in the images and getting their centres, angular orientation, pixel area. These dust particles are then highlighted on the images.
3. Trajectory tracking: Each dust cluster is assigned a unique identifying number. This number is used to access the cluster while deciding on its parent and children. Using a unique id also allows us to preserve the time information for each cluster
4. Plotting trajectories: This last step plots all the trajectories, the distributions