Hyperfly: Hyperspectral and Hypermodal Data Visualization Using Dragonfly

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With the advent of correlative and multimodal microscopy and in light of the recent developments in instrumentation, datasets are increasing in size and complexity. An added burden is thus laid on the analyst for the data interpretation. Multivariate tools are increasingly considered for their ability to take full advantage of the information available within spectral images. However, multivariate methods can be cumbersome and require advanced programming skills, which hinder their use for routine operations. In addition, proper visualization in 2D or 3D of the data is of paramount importance to fully understand the materials microstructure. Here, we present *HyperFly*, a new module that is added to *Dragonfly* [1], a software specialized for 2D, 3D and also 4D (i.e. 3D spatial + 1D temporal) data visualization.

Dragonfly's *HyperFly* plug-in is a user-friendly, Python™ based, interface for hyperspectral images processing. *HyperFly* includes numerous multivariate algorithms and hyperdimensional methods for autonomous classification and is being continuously updated with the latest advancement. In addition, Dragonfly's open-code architecture allows the user to modify or add any desired methods. The currently available algorithms are: Principal Component Analysis, Independent Component Analysis [2], Multivariate Curve Resolution - Alternative Least Square [3] and Multivariate Curve Resolution - LogLikelihood Maximization [4] and work is underway to include Bayesian Linear Unmixing [5]. HyperFly can import .h5, .dm3 and .dm4 native files, visualize and analyze the data using some of the available classifications algorithm (Figure 1A). The generated component spectra and corresponding contribution maps facilitates qualitative and quantitative interpretation of the chemical nature and spatial distribution in samples (Figure 2A-C). As part of Dragonfly, it becomes easy to take advantage of the software's comprehensive data visualization functions that can be supported with machine learning and deep learning. Those functions allows further quantitative analyses: particle counting, measurements (Fig. 2D) and classification.

We can use *Dragonfly's HyperFly* plug-in to analyze the spectral information of different co-registrated datasets (e.g. EELS-EDX, AFM-EDX) (Figure 1B). The user can benefit from the complementary information provided by different acquisition methods thus improving the accuracy of the classification of similar species. The plugin is designed to accommodate as many modalities as desired. Lastly, the hyperdimensional environment also offer an interface for tomographic visualization (i.e. 3D spectral volumes). With respect to *Tomviz* [6], *HyperFly* includes powerful multivariate tools for classification. Rooted in *Dragonfly*'s environment, *HyperFly's* user can access the extensive 3D visualization tools that are unavailable to other emerging data analysis platforms, such as *HyperSpy* [7][8].

References

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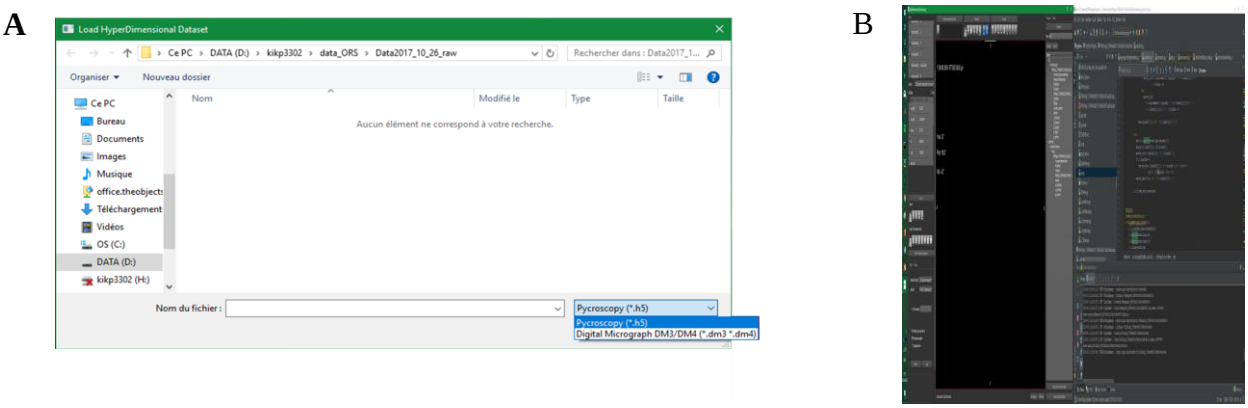

Figure 1 - Screenshot of Dragonfly HyperFly plug-in. A) Importation window allowing to read native .h5, .dm3 and .dm4 files B) Setup window allows the user to specify the selected dataset(s), the classification algorithm, the number of component and, if multiple dataset are selected, specify if they represent multimodal acquisition or a tomographic series.

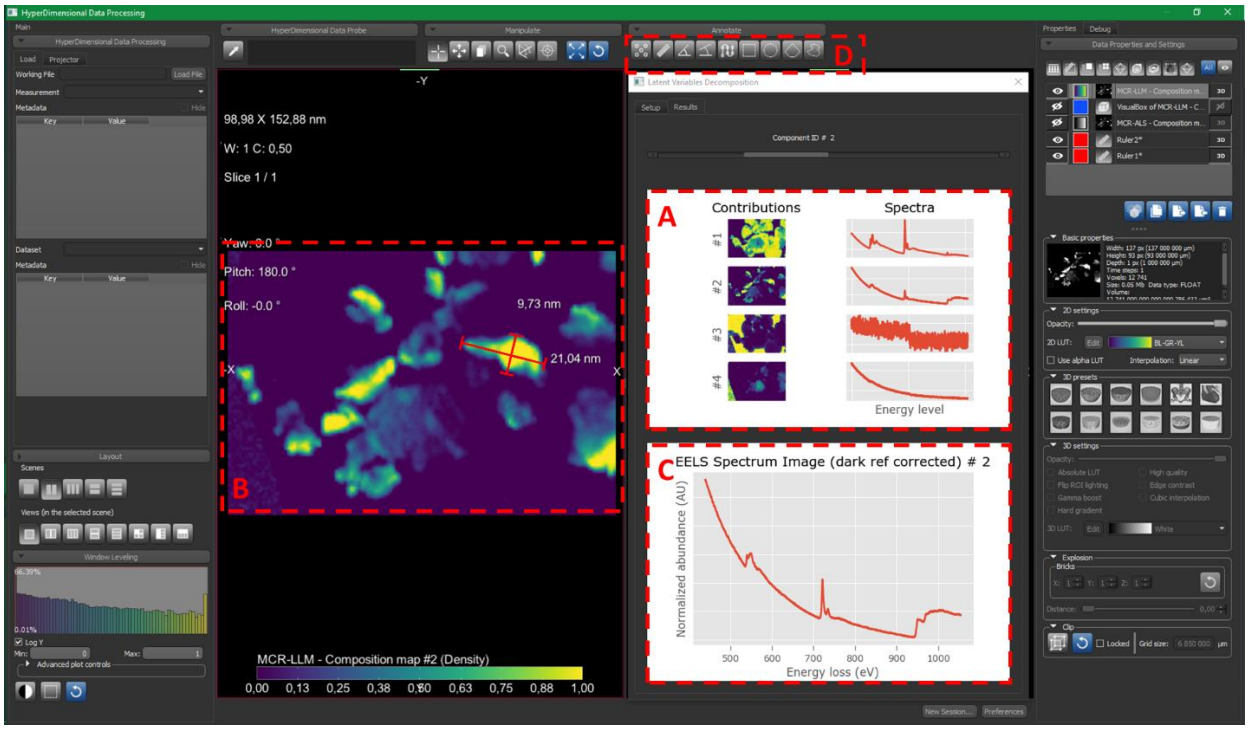

Figure 2 - Screenshot of Dragonfly HyperFly plug-in. A) Overview of the classification performed by MCR-LLM on an EELS acquisition of FeCu particles B) Enlargement of the selected component spectrum. C) Enlargement of the selected component contribution map D) Some of Dragonfly's basic measurement option, the ruler tool (second from the left) allows the annotations in B.