The 4DN-OME ontology: an OME-OWL extension with emphasis on usability, minimum information guidelines and quality control for super-resolution fluorescence microscopy

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Abstract. The Open Microscopy Environment (OME) model [1] is a specification for sharing biological imaging data that stores metadata as OME-XML. The OME Consortium recently introduced the OME core-ontology [2, 3] as a basis to facilitate the introduction of domain-specific metadata extensions. The 4D Nucleome [4] is an NIH initiative that funds ~600 researchers in ~50 independent laboratories. A central aim is to map the localization of single genomic loci obtained by fluorescence microscopy onto global chromatin topology maps obtained by Chromatin Conformation Capture (CCC) experiments. As part of this effort, the 4DN Imaging Data Working Group (IWG) is proposing the 4DN-OME ontology, an extension of the OME-core ontology, specifically tailored at enhancing the reproducibility and comparison of single-molecule, super-resolution fluorescence microscopy experiments. To reduce the record-keeping burden imposed by the proposed guidelines, the interactive Micro-Meta App was developed to guides experimental biologists through the workflow required to document tier-dependent hardware specifications. This poster presents the proposed 4DN-OME ontology and reports on the status of underlying application development.

Keywords: *Open Microscopy Environment, 4D Nucleome, super-resolution microscopy, imaging ontology, data provenance, quality control*

1 Introduction

Because the information content of image data is not machine-readable, microscopy images need to be accompanied by thorough documentation of the microscope hardware and imaging settings to ensure a correct interpretation of the results. A significant challenge with the reproducibility of microscopy results and with their integration with chromatin folding maps generated by the 4DN consortium lies in the lack of shared super-resolution microscopy reporting guidelines and of instrument performance and

calibration standards. The proposed 4DN-OME ontology is put forth as an extension of the OME core-ontology to help address this challenge.

2 The 4DN-OME ontology

The 4DN-OME ontology is being developed on the basis of the proposed 4DN extension [5] of the OME xml model. This proposed ontology has the following key features: 1) a tiered-system of reporting guidelines that scales required metadata content with experimental complexity. 2) A metadata model designed to better capture the technical complexity of high-resolution single-molecule localization and single-particle tracking experiments. 3) The introduction of standards for fluorescence microscope calibration and quantitative instrument performance assessment. In addition to introducing the concept of graded documentation requirements based on a tiered-system of guidelines, the 4DN-OME proposal extends the existing the OME core-classes `Instrument' and `Image' to reflect the technological advances and the quality control requirements associated with single-molecule, super-resolution microscopy. To this aim, the proposal put forth several types of modifications. First, additional classes and attributes were introduced to capture the complexity of microscope hardware commonly encountered in the field and their calibration requirements. Second, abstract concepts were proposed to describe hardware components that commonly require specialization (i.e., 'Detector'). Finally, the concept of individual 'WavelengthRange' class was established to facilitate the description of multi-pass filters, and dichroic-mirrors.

3 Development of Micro-Meta App

Micro-Meta App [6] provides an interactive future-proof approach to document imaging experiments based on the 4DN-OME ontology and the proposed tiered-system of guidelines. The user's data processing workflow consists of the following steps: 1) The App helps users build graphical representations of the microscope hardware by dragging-and-dropping individual components onto the workspace and entering the relevant attribute values based on the desired tier level. 2) Micro-Meta App builds tier-specific instances of `Instrument' class containing structured descriptions of the microscope hardware and outputs them as interoperable JSON files that can be shared with the community. 3) Finally, Micro-Meta App consumes these JSON documents, collects instrument-specific and tier-appropriate image acquisition settings, and stores them in the instances of `Image' class. The resulting documentation of individual microscopy datasets can be stored on the user's file system or consumed by third-party data portals.

References

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