

# CellView: an Interactive Image Viewer for Multiplex Cancer Images in the AstroPath Project

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We present CellView, a web-based image viewer built using free and open-source software components that aims to provide some of the basic functionality available in more sophisticated commercial image analysis tools used in digital pathology, such as HALO. CellView is designed as a three-tier application with a rich single-page viewer client, tile server middleware, and a SQL database storing imagery and spatial features. We are using the OpenLayers JavaScript library to display high-resolution tissue imagery, cell geometry and region annotations in a scalable manner using a hierarchy of image tiles, allowing for smooth transition between zoom levels. Image rendering tasks are distributed between the client and the tile server, simpler vector graphics and color adjustments performed on the client and more complicated rendering assigned to the tile server. This, combined with efficient spatial indexing at the database level, allows for fast rendering of thousands of cells with minimal delay while zooming or scrolling, using an underlying space-filling curve (Morton z-index). Various region metadata (pathological tissue annotations, field outlines, outlines of cell membranes and cell nuclei) are stored as GIS polygons. Rendering of polygons is also done on a per tile basis. Our indexing enables us to render cells straddling tile boundaries correctly. Visualization of cells is handled by switching between multiple methods, depending on the level of detail, from many cells per screen pixel to many pixels covering a single cell.

Another interesting feature is the user-defined color mixing of the images. For speed the color mixes are performed server side and a JPEG compressed color tile is sent to the client, but the users are able to specify a mixing matrix of the 8 (or more) image layers applied on the server. The client UI, built using the Vue.js framework, provides many customization options, including color and transparency settings for imagery layers and geometrical features, cell filtering settings, and configurable user-defined and predefined region annotation layers. Customization presets can be saved either on the client-side in a browser's local storage, or in a database on the server side. The CellView will soon host data about close to a billion cells for the public as part of an Open Cancer Cell Atlas.

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