Next generation of raster support for the GeoTools-GeoServer stack

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Outline

- Past achievements
- GDAL-ImageIO integration through ImageIO-ext
- RasterSymbolizer
- PostGISRaster
- Multidimensional spatiotemporal coverage support
Past Achievements

- GeoTools improved coverage I/O (through JAI-Image I/O)
  - Tiling
  - Overviews
  - Decimation on reading
  - Mosaicking
  - Compression
- GeoServer coverage support for WMS
- Brand-new GeoServer WCS 1.0 service (OGC Compliant)
- GeoServer WMS raster output formats (through JAI-Image I/O)
- GeoServer WMS on the fly palette generation and color inversion
- Base statistics operations for GeoTools
  - Extrema (support for spatial ROI)
  - Histogram (support for spatial ROI)
GDAL – JAI Image I/O Integration

• **SUN JAI** (High performance image processing library):
  - Deferred Execution Model + Operation chaining (Load Data only when need it)
  - Image Tiling + Tile Caching + Tile Scheduling
  - Many ready to use high performance operations
  - Native accelerated operations available for various platforms

• **SUN Image I/O**:
  - Pluggable and extensible architecture
  - Reader/writer plugins
  - Metadata management

• **SUN JAI – Image I/O**
  - ImageRead operation ties ImageReaders to JAI processing
  - ImageWrite operation ties ImageWriters to JAI processing

• **GDAL**
  - Do I need to talk about it?
Image I/O - Architecture

- Pluggable Architecture: SPIs and plugins

**Registry capabilities for SPIs**

- ImageReaderSPI
- ImageWriterSPI

- ImageReader
- ImageWriter

- IIOMetadataFormat
- IIOMetadata

- ImageReadParam
- ImageWriteParam

**Reading Capabilities**

**Metadata Management**

**Writing Capabilities**

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Image I/O – Read/Write Concepts

- Subsampling (decimation on read-write)
- Tiling
- Multimage file access (i.e. Tiff)
- SourceRegion/DestinationRegion selection
- SubBand selection
- Compression/Decompression
- Progress Listener capabilities
Image I/O - Metadata

- Image Metadata & Stream Metadata
  - IOMetadata vs IIOMetadataFormat
  - Multiple sets supported
  - XML DOM vs Java classes
- Transcoding
Image I/O-ext

- Extends SUN's Image I/O architecture
- Core libraries
  - Gdalframework
  - Customstreams
  - Imagereadmt
  - Jhdf4
  - Grib1 (spike)
- Plugins
  - Jpeg (gdal), geotiff (gdal), jp2kakadu (gdal), directkakadu, ecw (gdal), mrsid (gdal), arcgrid (gdal), javaarcgrid (arcgrid), hdf4 (gdal), swan
- https://imageio-ext.dev.java.net/
GDAL framework

- Started as a GSOC 06 project by Daniele Romagnoli
- Adapt GDAL SWIG Java bindings model to the SUN's Image I/O architecture to
  - GDAL driver ↔ Image I/O Reader/Writer
  - Translates Image I/O semantics into GDAL semantics
  - Acts as a base framework for GDAL oriented plugins
- Easily create new ImageReader/ImageWriter from existing GDAL driver
- Few improvements to the GDAL bindings
  - Multiband reads (Dataset read vs RasterBand read)
  - PixelInterleaved compliant reads (rendering)
  - Available as a patch
RasterSymbolizer

- SLD 1.0
- Goals
  - Render raw data
    - DEM, scientific models
    - Multispectral rasters
  - Enhance contrast
  - Sub-band selection
  - Opacity management
  - Mosaicking order management
- Graph (directed acyclic graph) of operations
- http://svn.geotools.org/geotools/branches/2.4.x_rs/
RasterSymbolizer

- Geometry
- **Opacity**
- **ChannelSelection**
  - (from whatever to RGB or Gray)
- OverlapBehavior
- **ColorMap**
- **ContrastEnhancement**
  - (Histogram Enhancement, Gamma correction)
- ShadedRelief
- ImageOutline
RasterSymbolizer - ColorMap

- Apply color maps (palette) to single band raw data through intervals specification (categories)
- Honour input NoData
- Be tolerant with gaps in input categories
- Be tolerant with NoData overlapping “real” categories
- Support 255 or 65535 colors
- Support opacity on single color map entries
- Allow users to map:
  - Intervals to color ramps
  - Intervals to single color (EXTENSION)
  - Single values to single colors (EXTENSION)
<ChannelSelection>
  <Gray><SourceChannelName>1</SourceChannelName></Gray>
</ChannelSelection>

<ColorMap type="values" extended="false">
  <ColorMapEntry color="#ff0000" quantity="20" opacity="1.0"/>
</ColorMap>

<ColorMap type="ramps" extended="false">
  <ColorMapEntry color="#7cfc00" quantity="50" opacity="1.0"/>
  ....
  <ColorMapEntry color="#8b4513" quantity="1000" opacity="1.0"/>
</ColorMap>

<ColorMap type="intervals" extended="false">
  <ColorMapEntry color="#7cfc00" quantity="50" opacity="1.0"/>
  ....
  <ColorMapEntry color="#8b4513" quantity="1000" opacity="1.0"/>
</ColorMap>
RasterSymbolizer – Contrast Enh.

- Enhance contrast to:
  - Highlight hidden *features*
  - Improve visual experience

- Histogram enhancement, various algorithms:
  - Histogram equalization
  - Histogram normalization (*contrast stretch*)
  - Many others...

- Gamma Correction

*Limitation*, we work only with 8 bits data
RasterSymbolizer – Contrast Enh.

- Exponential
- Logarithmic
- Equalization
- LinearStretch with Saturation
- Gaussian Stretch
- Gamma (brighten)
- Piecewise

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PostGISRaster

- Support for high resolution raster with overviews
- Support for complex spatiotemporal raster (nD data)
- Why using a DBMS:
  - Exploiting existing support for metadata (ISO 19115, 19139)
  - Exploiting existing spatial and temporal indexing
  - Investigate data ingestion option (open issue)
- Producing schema and I/O classes
- Producing (robust) tools to preprocess data
- Integration with PostGRID project (http://seagis.sourceforge.net)
- Why PostGIS?
PostGISRaster

[Diagram showing raster data structure and levels]

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PostGIS Raster – T and Z

- **Time Management**
  - Sequence of 2.5D snapshots
  - Temporal ranges $[T_1, T_2]$ with Nearest Neighbor interpolation
  - B-Trees (logarithmic access) to improve performances

- **Elevation Management**
  - Sequence of 2D layers
  - Positions values with Nearest Neighbor interpolation
  - B-Trees (logarithmic access) to improve performances
PostGISRaster – 2D slice

- Create a regular tessellation of original data
  - Work in raster space
  - Save georeferencing
  - Save original translation factors
- Tile integer indexing
  - Optimize most frequent case (TMS like approach)
  - Simplified tile lookup (no DBMS query)
  - Integer arithmetic + Recomposition by simple translation \( \rightarrow \) High Perf
  - Tile Caching highly simplified
- Multiband Tiles
- Consider MetaTiling
  - Reduce file access
nD Coverage Support

- Supporting coverage with complex domain \((t,z,l,b,y,x)\) and complex codomain (e.g. Multispectral data).

- 2 levels of work
  - Well-known formats
    - Hdf4, HDF, Grib1, SWAN, COAMPS (GeoSolutions)
    - NetCDF, HDF (Geomatys)
  - Metadata and indexing (common middleware)
    - Cooperation GeoSolutions – GeoMatys

- Goals:
  - GeoServer WCS 1.1 with full spatiotemporal support
  - GeoServer WMS 1.1.1 with full temporal and elevation support
nD Coverage Support

GeoTools Multidim plugin

ImageIO “smart” reader
generic wrapper

Coverage, t, z, i, j, B, y, x

ImageIO “smart” reader
specific wrapper

Depending on the specific request, we should also choose the best resolution level available.

ImageIO “flat” reader
format specific

Image metadata
(for each Image)

NCSDF, GRIB, HDF, SWAN, ...

AbstractImageReader

GRIB1ImageReader

AbstractSpatioTemporalReader

GRIB1SpatioTemporalReader

Image IO “smart” reader

Coverage metadata

Stream metadata

* Indexes should be built without parsing metadata by the specific “smart” reader, in order to have better performance. Metadata are built on-demand.

* The reader handles spatio-temporal information using also GeoTools (as it should inspect the several ImageFiles pairs and group them in overviews).

Renders the spatio-temporal logic

As much as possible compatible with I/O readers/writers
nD Coverage Support

- **Stream Metadata**
  - Brief description of a source's content
  - Similar to WCS GetCapabilities
  - Brief description each coverage

- **Coverage Metadata**
  - Detailed description of a coverage
    - Domain, Range, Overviews...
  - May point to external set of metadata (ISO 19115, 19139)

- **Image Metadata**
  - Detailed description of a 2D slice
    - Raster geometry, band structure
  - Description of exploitation metadata
    - No data values, calibration offset and calibration scale, raster statistics
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// prepping to read
final ParameterBlockJAI pbjImageRead;
final ImageReadParam irp = new ImageReadParam();

// subsample by 8 on both dimensions
final int xSubSampling = 8;
final int ySubSampling = 8;
final int xSubSamplingOffset = 0;
final int ySubSamplingOffset = 0;
irp.setSourceSubsampling(xSubSampling, ySubSampling,
xSubSamplingOffset, ySubSamplingOffset);

// re-tile on the fly to 512x512
final ImageLayout l = new ImageLayout();
l.setTileGridXOffset(0).setTileGridYOffset(0).setTileHeight(512).
.setTileWidth(512);

pbjImageRead = new ParameterBlockJAI("ImageRead");
 pbjImageRead.setParameter("Input", file);
 pbjImageRead.setParameter("readParam", irp);

// get a RenderedImage
RenderedOp image = JAI.create("ImageRead", pbjImageRead,
new RenderingHints(JAI.KEY_IMAGE_LAYOUT, l));
<xsd:complexType>
  <xsd:complexContent>
    <xsd:extension base="sld:SymbolizerType">
      <xsd:sequence>
        <xsd:element ref="sld:Geometry" minOccurs="0"/>
        <xsd:element ref="sld:Opacity" minOccurs="0"/>
        <xsd:element ref="sld:ChannelSelection" minOccurs="0"/>
        <xsd:element ref="sld:OverlapBehavior" minOccurs="0"/>
        <xsd:element ref="sld:ColorMap" minOccurs="0"/>
        <xsd:element ref="sld:ContrastEnhancement" minOccurs="0"/>
        <xsd:element ref="sld:ShadedRelief" minOccurs="0"/>
        <xsd:element ref="sld:ImageOutline" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
PostGIS Raster – Schema
nD Coverage Support

StreamMetadata

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nD Coverage Support

Coverage Metadata

Image Metadata

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