

PYGILE-PLUS: COMPLETE ALGORITHMS REFERENCE GUIDE

OVER 1700+ GEOSPATIAL PROCESSING ALGORITHMS

EXECUTIVE SUMMARY

PyGILE-Plus provides access to **1700+ algorithms** across five major geospatial processing platforms:

- **QGIS:** 400+ native and plugin-based processing algorithms
- **GRASS GIS 8.4:** 500+ modules for comprehensive spatial analysis
- **SAGA GIS 9.3:** 600+ geoprocessing tools for terrain and image analysis
- **Orfeo ToolBox (OTB) 9.1:** 100+ remote sensing and image processing algorithms
- **WhiteboxTools:** 480+ specialized geospatial analysis tools

Summary Statistics

Platform	Primary Domain	Algorithm Count	Key Strengths	Version
QGIS	General GIS	400+	Versatile, user-friendly, plugin ecosystem	LTR 3.40
GRASS GIS	Spatial analysis	500+	Topology, temporal analysis, scripting	8.4.0
SAGA GIS	Terrain analysis	600+	Morphometry, geostatistics, modeling	9.3.2
OTB	Remote sensing	100+	Image processing, machine learning	9.1.1
WhiteboxTools	Specialized analysis	480+	Performance, hydrology, LiDAR	Latest
Python Ecosystem	Programming interface	100+	Automation, custom workflows, integration	3.11

QGIS Processing Algorithms (~400 tools)

Core Native Algorithms

Category	Algorithm Examples	Count
Vector Analysis	Buffer, Intersection, Union, Difference, Dissolve, Clip, Overlay operations	40+
Raster Analysis	Raster calculator, Zonal statistics, Reclassify, Proximity analysis	35+
Vector Processing	Centroid, Convex hull, Simplify, Smooth, Fix geometries, Extract vertices	30+
Database Operations	Join attributes, Field calculator, Refactor fields, Extract by attribute	25+
Interpolation	IDW, TIN, Grid interpolation, Heatmap generation	15+
Geometric Operations	Translate, Rotate, Scale, Affine transformations, Create grid	20+
File Management	Package layers, Export layers, Download from web services	15+

GDAL/OGR Integration

Function	Tools	Count
Data Conversion	Translate, Warp, Merge, Build VRT, Rasterize, Polygonize	25+
Raster Processing	Contour generation, Hillshade, Color relief, DEM processing	20+
Vector Operations	Dissolve, Buffer, Clip, Transform, Reproject	15+
Analysis Tools	Grid metrics, Proximity, Sieve, Nearblack filtering	12+

Additional Processing Providers

Provider	Specialty	Algorithm Count
Native QGIS	Core GIS operations	150+

GDAL	Data I/O and basic analysis	72+
Network Analysis	Shortest path, service areas, traveling salesman	15+
Cartography	Layout tools, symbology helpers	25+
3D Analysis	Terrain profiling, viewshed analysis	10+

GRASS GIS 8.4 Modules (~500 tools)

Display Modules (d.*)

Module	Description	Count
d.rast*	Raster display and visualization	15+
d.vect*	Vector display and cartographic output	12+
d.his	HIS color space operations	8+
d.graph	Graphics and annotation tools	10+

General Modules (g.*)

Module Category	Description	Count
g.gui*	Graphical user interface tools	15+
g.extension	Add-on management system	5+
g.proj	Projection and coordinate system tools	8+
g.region	Computational region management	6+
g.list	Data management and inventory	10+

Raster Modules (r.*)

Category	Key Modules	Count
Hydrology	r.watershed, r.drain, r.flow, r.stream.extract, r.water.outlet	25+
Terrain Analysis	r.slope.aspect, r.param.scale, r.geomorphon, r.horizon	30+

Statistics	r.statistics, r.univar, r.regression.line, r.covar	20+
Interpolation	r.surf.idw, r.surf.rst, r.fillnulls, r.resamp.*	15+
Classification	r.cluster, r.kappa, r.reclass, r.recode	12+
Math/Calc	r.mapcalc, r.series, r.neighbors, r.patch	25+
Import/Export	r.in., <i>r.out.</i> , r.external, r.pack	20+
Solar/Climate	r.sun, r.sunhours, r.sunmask	8+

Vector Modules (v.*)

Category	Key Modules	Count
Analysis	v.overlay, v.buffer, v.distance, v.select, v.extract	25+
Network	v.net.*, v.net.path, v.net.alloc, v.net.iso	15+
Topology	v.build, v.clean, v.category, v.centroids	12+
Database	v.db.*, v.to.db, v.what.rast, v.sample	18+
Interpolation	v.surf.bspline, v.surf.idw, v.surf.rst, v.vol.rst	8+
Import/Export	v.in., <i>v.out.</i> , v.external, v.pack	15+

Image Processing Modules (i.*)

Category	Key Modules	Count
Classification	i.cluster, i.maxlik, i.smap, i.segment	12+
Enhancement	i.colors.enhance, i.pca, i.his.rgb, i.rgb.his	15+
Atmospheric	i.atcorr, i.landsat.toar, i.aster.toar	8+
Spectral	i.vi, i.albedo, i.emissivity, i.biomass	10+

Temporal Modules (t.*)

Category	Description	Count
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Space-Time Raster	t.rast.*, temporal raster analysis	25+
Space-Time Vector	t.vect.*, temporal vector analysis	12+
Space-Time 3D	t.rast3d.*, 3D temporal analysis	8+

SAGA GIS 9.3 Tools (~600 tools)

Climate and Weather

Tool Group	Examples	Count
Climate Tools	Temperature analysis, precipitation modeling	15+
Weather Simulation	Wind modeling, evapotranspiration	10+

Geostatistics

Tool Category	Description	Count
Kriging	Ordinary, universal, simple kriging variants	12+
Regression	GWR, multiple regression, trend analysis	15+
Variogram	Variogram modeling and analysis	8+
Point Statistics	Spatial autocorrelation, point pattern analysis	10+

Grid Analysis

Category	Tools	Count
Grid Calculus	Mathematical operations, statistical analysis	25+
Grid Filter	Smoothing, edge detection, morphological filters	30+
Grid Tools	Merging, resampling, aggregation	20+
Grid Gridding	Interpolation methods, surface generation	15+

Image Analysis

Category	Description	Count
Classification	Supervised/unsupervised classification methods	20+
Segmentation	Region growing, watershed segmentation	15+
Enhancement	Filters, histogram operations, PCA	25+
Feature Extraction	Texture analysis, edge detection	18+

Import/Export

Format Category	Supported Formats	Count
Raster Formats	GeoTIFF, ESRI Grid, NetCDF, various image formats	25+
Vector Formats	Shapefile, KML, DXF, GPX	15+
Point Cloud	LAS, LAZ, ASCII point clouds	8+
Database	PostGIS, SQLite, ODBC connections	10+

Projection

Category	Tools	Count
Coordinate Systems	Transformation, reprojection tools	12+
Georeferencing	Ground control points, rectification	8+

Simulation

Domain	Applications	Count
Hydrology	Flow simulation, erosion modeling	15+
Erosion	USLE, sediment transport	8+
Fire Spread	Wildfire modeling, risk assessment	5+

Terrain Analysis

Category	Key Tools	Count
Morphometry	Slope, aspect, curvature, TPI, TWI	25+
Hydrology	Flow direction, accumulation, watersheds	20+
Lighting	Hillshading, sky view factor, solar radiation	12+
Classification	Landform classification, geomorphons	10+
Channels	Stream network extraction, channel properties	15+

Table Tools

Category	Description	Count
Data Management	Import, export, field calculations	15+
Statistical Analysis	Descriptive statistics, correlations	12+

Vector Analysis

Category	Operations	Count
Geometric Operations	Buffer, intersection, union, difference	20+
Spatial Relations	Distance analysis, nearest neighbor	15+
Point Analysis	Clustering, density analysis	12+

Orfeo ToolBox (OTB) 9.1 (~100 applications)

Basic Filtering

Category	Applications	Count
Spatial Filtering	Smoothing, edge detection, morphological operations	15+
Spectral Processing	Band math, indices computation, PCA	12+
Noise Reduction	Denoising, artifact removal	8+

Feature Extraction

Category	Description	Count
Texture Analysis	Haralick textures, local statistics	10+
Edge Detection	Canny, Sobel, gradient-based methods	8+
Interest Points	SIFT, SURF, Harris corners	6+
Line Detection	Linear feature extraction	4+

Geometric Processing

Category	Tools	Count
Orthorectification	Sensor model-based geometric correction	5+
Image Registration	Feature-based, area-based matching	8+
Stereo Processing	Disparity mapping, DSM generation	6+
Superimposition	Image fusion, mosaicking	4+

Learning Applications

Category	Methods	Count
Supervised Classification	SVM, Random Forest, Neural Networks, Bayes	10+
Unsupervised Classification	K-means, SOM	4+
Regression	Support Vector Regression, Random Forest Regression	5+
Validation	Confusion matrix, accuracy assessment	3+

Object-Based Analysis

Category	Applications	Count
Segmentation	Mean-shift, watershed, region growing	8+
Object Classification	Shape-based, spectral-based classification	5+
Object Features	Geometric, radiometric, textural features	6+

Radiometric Processing

Category	Tools	Count
Atmospheric Correction	6S model, DOS, SMAC	6+
Sensor Calibration	DN to radiance/reflectance conversion	8+
Optical Calibration	Relative/absolute radiometric calibration	4+

SAR Processing

Category	Applications	Count
SAR Calibration	Radiometric calibration, noise reduction	5+
Polarimetry	Polarimetric decompositions, classifications	6+
Interferometry	Coherence estimation, phase unwrapping	4+

WhiteboxTools (~480 tools)

Data Tools

Category	Description	Count
Import/Export	Format conversion, data translation	25+
Database Operations	Attribute manipulation, joins	15+
Data Quality	Error detection, validation	12+

GIS Analysis

Category	Tools	Count
Vector Analysis	Overlay operations, spatial joins, geometric analysis	40+
Distance Analysis	Proximity, cost distance, allocation	15+
Patch Analysis	Landscape metrics, connectivity analysis	20+

Hydrological Analysis

Category	Key Tools	Count
DEM Preprocessing	Depression filling, breach, conditioning	15+
Flow Analysis	Flow direction, accumulation, multiple algorithms	25+
Stream Network	Network extraction, ordering, topology	20+
Watershed	Delineation, subbasin analysis	12+
Wetness Indices	TWI, stream power, relative position	10+

Image Analysis

Category	Applications	Count
Classification	K-means, ISODATA, supervised methods	12+
Enhancement	Contrast, histogram operations, filters	20+
Segmentation	Region growing, edge-based methods	8+
Change Detection	Multi-temporal analysis	6+

LiDAR Analysis

Category	Tools	Count
Point Cloud Processing	Filtering, classification, statistical analysis	25+
Digital Surface Models	DSM/DTM generation, quality assessment	15+
Canopy Analysis	Height metrics, canopy structure	12+

Ground Classification	Bare earth extraction, vegetation filtering	10+
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Mathematical Operations

Category	Description	Count
Statistical Analysis	Descriptive stats, correlation, regression	20+
Mathematical Functions	Trigonometric, logarithmic, exponential	15+
Matrix Operations	Linear algebra, transformations	10+

Stream Network Analysis

Category	Specialized Tools	Count
Network Properties	Stream order, length, gradients	15+
Connectivity	Flow path analysis, network topology	12+
Longitudinal Profiles	Elevation profiles, knickpoint detection	8+

Terrain Analysis

Category	Key Algorithms	Count
Surface Derivatives	Slope, aspect, curvatures (multiple methods)	20+
Morphological Analysis	Landforms, relative position, local relief	25+
Hypsometric Analysis	Elevation distributions, landscape evolution	8+
Visibility Analysis	Viewshed, line of sight, visual exposure	10+

Python Ecosystem Integration

Core Scientific Libraries

Library	Purpose	Key Features
NumPy	Numerical computing	N-dimensional arrays, mathematical functions
Pandas	Data manipulation	DataFrames, time series, statistical analysis

SciPy	Scientific computing	Optimization, signal processing, statistics
Matplotlib	Visualization	2D plotting, publication-quality graphics
Scikit-learn	Machine learning	Classification, regression, clustering

Geospatial Python Libraries

Library	Specialty	Capabilities
GDAL/OGR	Data I/O	200+ raster/vector format support
Rasterio	Raster processing	NumPy integration, efficient I/O
Shapely	Geometric operations	Point, line, polygon operations
Fiona	Vector I/O	Clean vector data access
GeoPandas	Spatial DataFrames	Pandas + spatial operations
PyProj	Projections	Coordinate system transformations

Deep Learning Integration

Framework	Purpose	Integration
PyTorch	Neural networks	Custom model development
TensorFlow	Deep learning	Pre-trained models, training
Scikit-image	Image processing	Computer vision algorithms

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Total Algorithm Count: 1700+

Use Case Matrix

Application Domain	Primary Tools	Secondary Tools
Remote Sensing	OTB, SAGA	GRASS, Python
Hydrology	WhiteboxTools, GRASS	SAGA, QGIS
Terrain Analysis	SAGA, WhiteboxTools	GRASS, OTB
Vector Analysis	QGIS, GRASS	WhiteboxTools
Machine Learning	Python, OTB	SAGA, GRASS
Cartography	QGIS, GRASS	Python
LiDAR Processing	WhiteboxTools, OTB	GRASS, Python
Temporal Analysis	GRASS, Python	QGIS, SAGA

This document provides a comprehensive overview of the 1700+ algorithms available in the PyGILE-Plus environment. For detailed parameter information and usage examples, consult the individual tool documentation within each platform.