Professional Python Development in ArcGIS Pro

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High Quality PDF (2MB)

Introduction

Today's Presentation

Overview of ArcGIS Pro

- Work accomplished in the past year
- Tour of Documentation and Code samples
- Esri's open source participation and integration
- Explanation of Tool creation concepts

Product Engineer - Geoprocessing at Esri California (1 year 8 months)

- Python
- ArcPy
- Conda Integration
- C#/WPF
- Python Backstage
- Charts and Graphs
- Presentations

GIS Developer at Matrix Solutions in Calgary (2 years)

- Civil Engineering/Environmental Consultant Firm
- Created several dozen custom Geoprocessing tools in Python
- Customized ArcGIS with Python and C#/WPF

Esri ArcGIS

Setting up ArcGIS Pro

Windows Only

Free Windows VMs - http://bit.ly/FreeWindowsVM

Free ArcGIS Pro - (http://bit.ly/ArcPyProTrial

ArcPy Documentation - http://bit.ly/ArcPyDocs

Why ArcGIS? - Powerful and Proven technology

ARC/INFO released in 1982

Figure 1:

ArcGIS in 1999

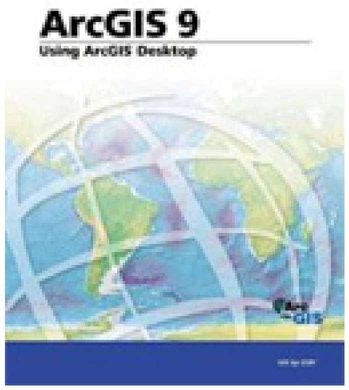


Figure 2:

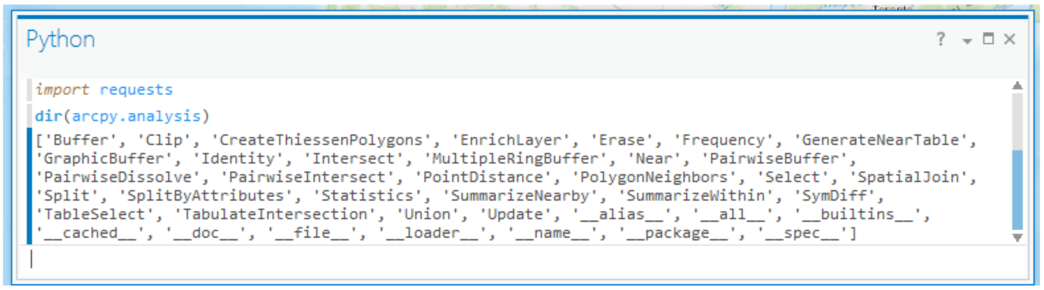
Why ArcGIS? - Powerful and Proven technology

ArcGIS Pro in 2015

Extensive Python Support:

- ArcPy
- ArcGIS Python API

Integrated Python Interpreter



```
import requests
dir(arcpy.analysis)
['Buffer', 'Clip', 'CreateThiessenPolygons', 'EnrichLayer', 'Erase', 'Frequency', 'GenerateNearTable',
'GraphicBuffer', 'Identity', 'Intersect', 'MultipleRingBuffer', 'Near', 'PairwiseBuffer',
'PairwiseDissolve', 'PairwiseIntersect', 'PointDistance', 'PolygonNeighbors', 'Select', 'SpatialJoin',
'Split', 'SplitByAttributes', 'Statistics', 'SummarizeNearby', 'SummarizeWithin', 'SymDiff',
'TableSelect', 'TabulateIntersection', 'Union', 'Update', '__alias__', '__all__', '__builtins__',
'__cached__', '__doc__', '__file__', '__loader__', '__name__', '__package__', '__spec__']
```

Figure 3:

Why ArcGIS? - Documentation

Second-to-None Documentation

Esri Blog - https://blogs.esri.com/esri/arcgis/category/subject-python/

Esri Press - http://esripress.esri.com/display/index.cfm

ArcGIS Help - https://pro.arcgis.com/en/pro-app/help/main/welcome-to-the-arcgis-pro-app-help.htm

GeoNet - https://geonet.esri.com

- Esri Forums/Social Network
- Python Community
- https://geonet.esri.com/community/developers/gis-developers/python

Why ArcGIS? - Versatility

Supports multiple GIS Applications

- ArcGIS Desktop (Includes ArcGIS Pro)
- ArcGIS Enterprise
- ArcGIS Online

Includes over 1000 Geoprocessing Tools

- From simple (Buffer, Spatial Join)
- To Complex (Space-Time Cube, Generate Tessellation)

Advanced Projection Engine

- Supports dozens of projections/transformations

Why ArcGIS? - Geospatial Data

Rich source of GIS Data

- ArcGIS Online provides thousands of ready-to-go data sets.
  - Living Atlas of The World
  - ArcGIS Online

Large selection of Plugins

- https://marketplace.arcgis.com/

Why ArcGIS? - Industry Standard

Included suite of cartographic symbology.

Industry Standard solution

- Used by Governments, Fortune 500 companies and Individuals.
  - Swiss Gov't examples (Canton Governments, Swiss Institute of Forest, Snow and Landscape Research etc)

Why ArcGIS Pro?

Modern View for ArcGIS:

- .Net 4.5 concurrency model
- Integrated 2D and 3D views
- In active development, New Features
- Modern Python Experience
- Supports environments and packages via Conda

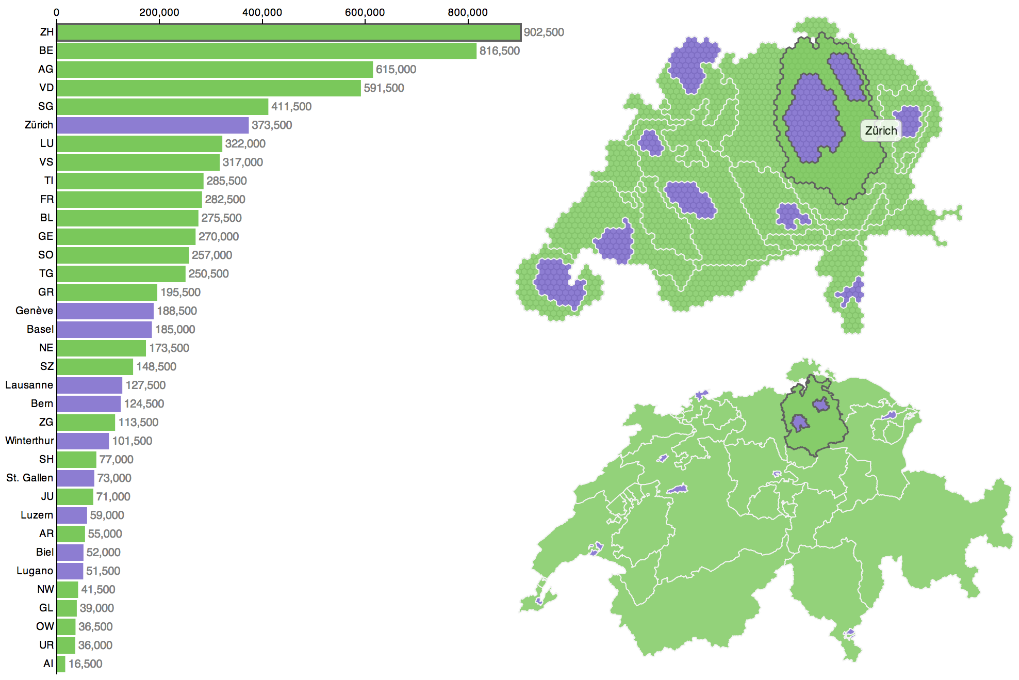
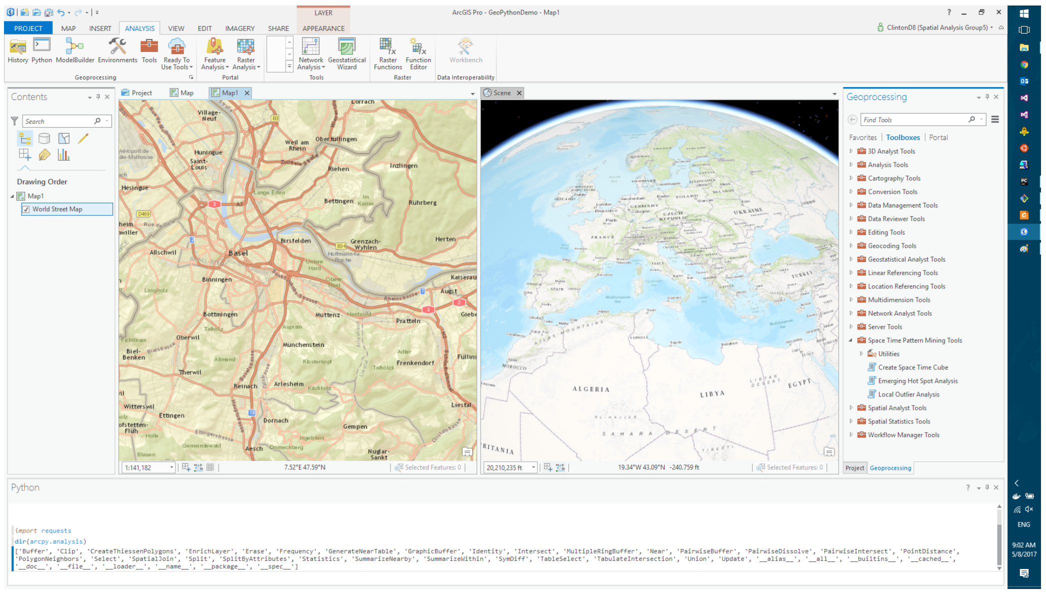


Figure 4:



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'__doc__', '__file__', '__loader__', '__name__', '__package__', '__spec__']
```

Figure 5:

ArcGIS Pro

Python Packages and Environments

Package Management on Windows

Using pip, wheels, virtualenvs

- Packaged with distributions of Python
- These tools handle the harder problem of system dependencies, considered out of scope by Python packagers — does it end up in site-packages?
- Package devs: On OSX and Linux, 'easy' to get the deps! Use a system package manager (e.g. apt, brew, yum)
- Included Compiler (e.g. clang, gcc).

Virtual Environments

What are Virtual Environments

- Self-contained instances of Python
- Seperate from main Python installation
- Can contain a unique set of packages
- Useful when working on multiple projects at one time

What about Windows?

Windows lacks broadly used package management

- Only developers have a C compiler on their machine (Typically Visual Studio)
- A hard problem for many organizations to reliably solve
- "Works on my machine but not yours" problem.
- Supporting users takes up valuable dev time
- No guarantee that customers will be supported

Enter Conda

CONTINUUM
ANALYTICS

CONDA

Why Conda?

Scientific Python community identified that there was a gap not being addressed by the core Python infrastructure, limiting their ability to get packages into the hands of users

Industry standard built by people who care about this space — Continuum Analytics

Handles dependencies for many languages (C, C++, R and of course Python)

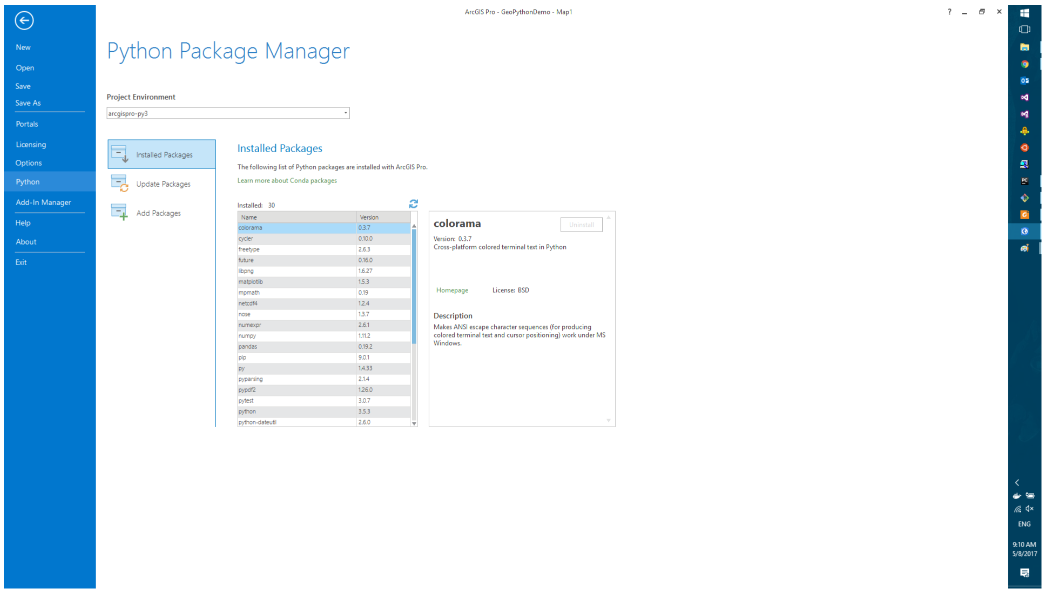
Built for Python first, but it really solves a much broader infrastructural issue.

Conda in ArcGIS Pro

Significant effort has been made at Esri to integrate the conda package manager and virtual environment experience into the ArcGIS Pro experience.

- Shipped with environment support
- In-app user interface
- Packaging effort for Esri Python code

Conda in ArcGIS Pro



Python Package Manager

Project Environment

arcgispro-py3

Installed Packages

The following list of Python packages are installed with ArcGIS Pro.

Learn more about Conda packages

Installed: 30

Name	Version
colorama	0.3.7
cycler	0.10.0
freetype	2.6.3
future	0.16.0
libpng	1.6.27
matplotlib	1.5.3
mpmath	0.19
netcdf4	1.2.4
nose	1.3.7
numexpr	2.6.1
numpy	1.11.2
pandas	0.19.2
pip	9.0.1
py	1.4.33
pyparsing	2.1.4
pypdf2	1.26.0
pytest	3.0.7
python	3.5.3
python-dateutil	2.6.0

colorama

Version: 0.3.7
Cross-platform colored terminal text in Python

License: BSD

Description

Makes ANSI escape character sequences (for producing colored terminal text and cursor positioning) work under MS Windows.

Figure 6:

Coming Soon

Support for custom channels

- Public Channels
- Private Channels

Package Creation via UI

- Currently only available in cmd line
- Share packages with colleagues and customers

Additional Support on Server

- Conda packages and environments fully supported on Enterprise
- ArcGIS Python API Notebooks served on Enterprise

Using Packages to our Advantage

Open Source Ecosystem

The Python Ecosystem includes thousands of open-source packages

Esri is using several packages in ArcGIS

- NumPy
- SciPy
- matplotlib
- Pandas (coming soon)

Open Source Ecosystem

Automate or Extend your ArcGIS capabilities

- Thousands of open-souce Python packages
- Conda-Forge community

Easily package and share your work

- Conda-build
- Anaconda.org
- Host packages on network

Setting up a Development Environment

What can we install? Not just scientific packages.

- Documentation
- Datasets
- GUI toolkits (PyQt, TKinter)
- Database Drivers (psycopg2)

- C++ Libraries (Boost)
- IDEs
  - Spyder
  - Juptyer

Setting up a Production Environment

Proven environments that will 'Just work'

- Solves 'works on my machine' problem
- Metapackages
  - Packages which only have requirements
- Environment.yaml
  - More complex requirements.txt

Working with Customers

Requirements Analysis

Determining user expectations for a new or modified product

- Identify Stakeholders
- Eliciting Requirements
- Stakeholder interviews
- Analyzing Requirements
- Clear
- Complete
- Consistent
- Recording Requirements
- User Stories
- Use Cases

Test Driven Development

Turning valid requirements into testable code

- Identifying units of work
- Preexisting tools?
- Defining functional extent of units
- Writing tests to encapsulate functionality

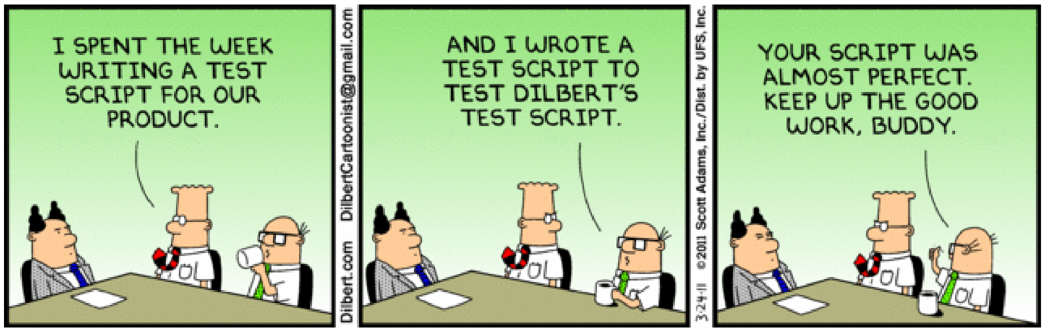

I SPENT THE WEEK WRITING A TEST SCRIPT FOR OUR PRODUCT.
AND I WROTE A TEST SCRIPT TO TEST DILBERT'S TEST SCRIPT.
YOUR SCRIPT WAS ALMOST PERFECT. KEEP UP THE GOOD WORK, BUDDY.
Dilbert.com DilbertCartoonist@gmail.com
3-24-11 ©2011 Scott Adams, Inc./Dist. by UFS, Inc.

Figure 7:

TDD in Python

Several test suites available

- Pytest
- Nose
- unittest

Efficient Testing with ArcPy

Extra considerations for Geospatial tools

- Data set types
- Feature Class (Geodatabase)
- Shapefiles (Esri Open-Source Format)

- GeoJSON (Generic Open-Source Format)
- Projections
- Data Frame (View)
- Data Sets
- UI interactions
- Data Validation

Version Control as a Communication Tool

What is Git?

Git

A distributed version control system.

- Originally made for linux developers
- Arguably the most popular open-source version control
- Heavily used in Conda packaging workflow

Why Git?

Features of Git that support Conda packaging

- Commit hash as version number
- Excellent for testing development versions
- Packages can ‘cherry-pick’ parts of repositories
- Production packages may not include tests etc.
- Develop with a team
- Intuitive branching and merging

What is Github

Github

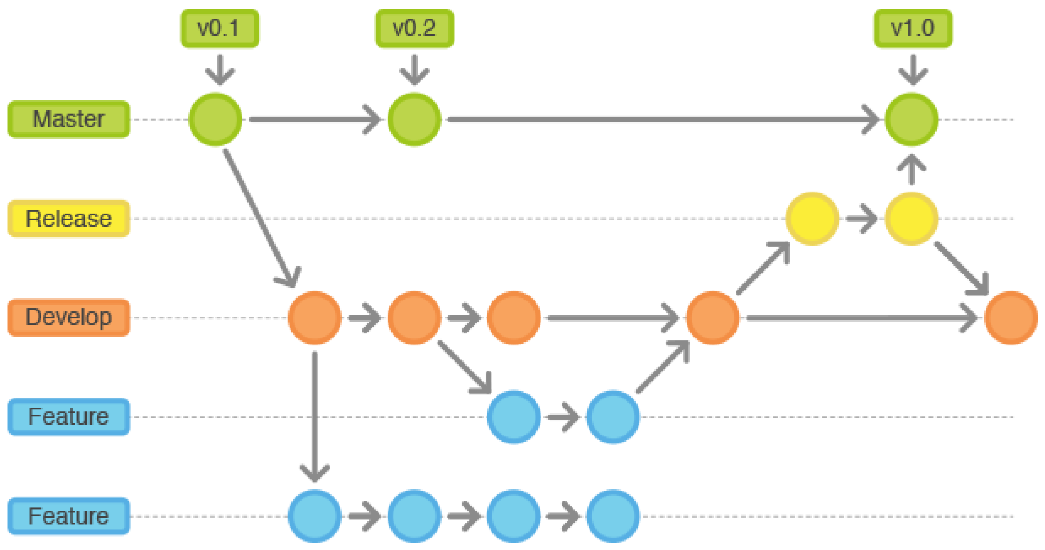


Figure 8:

Github promotes 'Social Coding' a combination of Version Control and Social Media

- Ease of Collaboration
- Ease of Communication
- Ease of Distribution

Esri on Github

- https://www.github.com/Esri
- https://www.github.com/arcpy

Github as a Communication Tool

Github offers several features which enhance communication - Issue tracking - Tags - User Notifications - Repository Forking - Create your own version of code

Beginner Python - Python Features in ArcGIS Pro UI

Python Window

Quick means of interacting with ArcGIS Pro using Python

- Good way to practice and test concepts
- View help documentation for ArcPy functions
- Import and Export Python Scripts

Interactive Selections

- Operate on data selected on Map
- Automatically show result in Map

Field Calculator

Leverage the power of Python to enhance your data sets

- Utilize Python to calculate new fields
- Available through Pro UI
- Extract code to Scripts
- Data access ArcPy module
- Calculate fields using Cursors without UI interaction

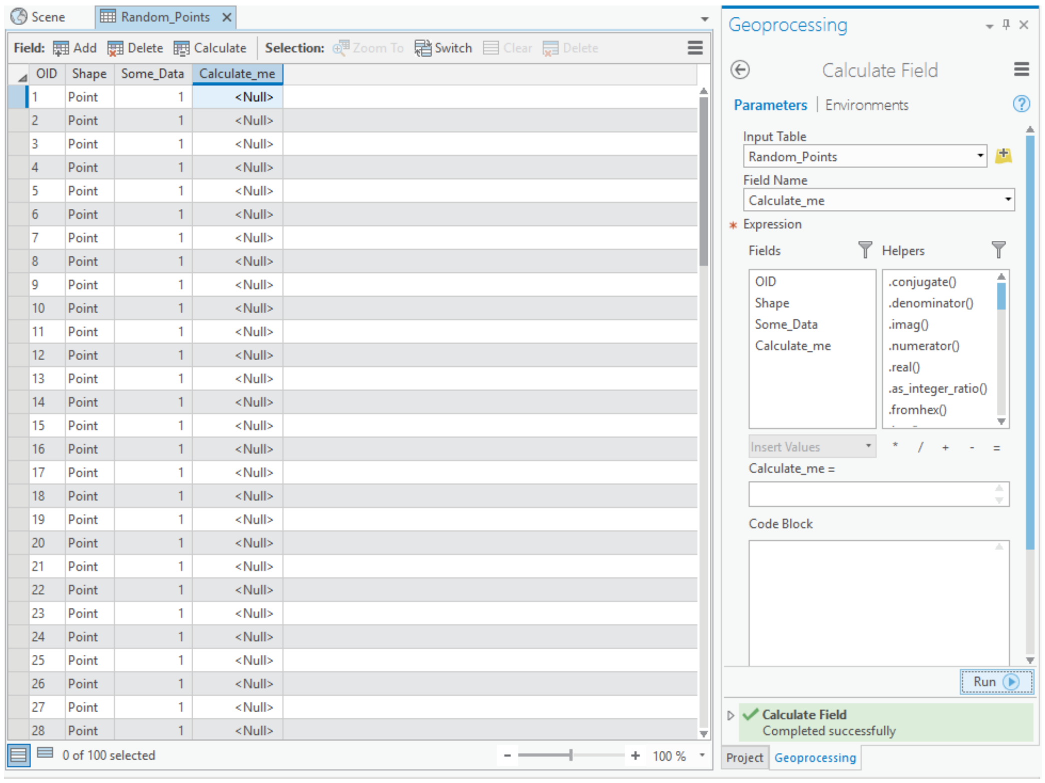
Intermediate Python - Creating Tools in ArcGIS Pro

TBX Toolboxes

The original ArcGIS toolbox. - Created via the ArcGIS GUI - Tool Validation not set in Python script - Set via 'Properties' menu of tool in ArcGIS

Python Toolboxes

ArcGIS toolboxes revisited in Python - All steps defined in a .pyt file - Ease of testing &



OID	Shape	Some_Data	Calculate_me
1	Point	1	<Null>
2	Point	1	<Null>
3	Point	1	<Null>
4	Point	1	<Null>
5	Point	1	<Null>
6	Point	1	<Null>
7	Point	1	<Null>
8	Point	1	<Null>
9	Point	1	<Null>
10	Point	1	<Null>
11	Point	1	<Null>
12	Point	1	<Null>
13	Point	1	<Null>
14	Point	1	<Null>
15	Point	1	<Null>
16	Point	1	<Null>
17	Point	1	<Null>
18	Point	1	<Null>
19	Point	1	<Null>
20	Point	1	<Null>
21	Point	1	<Null>
22	Point	1	<Null>
23	Point	1	<Null>
24	Point	1	<Null>
25	Point	1	<Null>
26	Point	1	<Null>
27	Point	1	<Null>
28	Point	1	<Null>

0 of 100 selected

Input Table: Random_Points

Field Name: Calculate_me

* Expression

Fields: OID, Shape, Some_Data, Calculate_me

Helpers: .conjugate(), .denominator(), .imag(), .numerator(), .real(), .as_integer_ratio(), .fromhex()

Calculate_me =

Code Block

Calculate Field
Completed successfully

Figure 9:

debugging - Validation defined within script - Works with Python IDEs - Define .pyt as a Python file type in settings - Syntax Highlighting - Autocomplete

Python Toolboxes

Python Toolbox (.pyt) Files - Toolbox Class - **init** - self.tools - Tool Class - **init** - Validation - Logic

Tool Validation

ArcGIS Supports Dozens of Data Types - Ensure the inputs supplied by the user are valid - Dynamically populate fields with values - Inform users when unexpected or unusable data is present

Input/Output Parameters

Defining Parameters Working with Input Parameters - GetInputParameter - GetInput-ParameterAsText - Parameters from Command Line Working with Output Parameters - Schema - ParameterDependencies

getParameterInfo

Populate the values of a Tool’s Parameters - Called when the tool is opened. - Populate input parameters with inital values

updateParameters

Refine and Modify the values of a Tool’s Parameters - Called whenever a parameter has been changed in the ArcGIS GUI - Frequent calls - Make method ‘inexpensive’ if possible - May use ‘global’ values to store results after first call

updateMessages

Modify the Messages created when a Tool's Parameters have changed - Called after validation has been performed. - Display a Warning or Error to users if Parameters have bad values

isLicensed

Query the license system to ensure the tool can run at the current license level. - Checking for licenses

execute

The tool's source code which is run upon tool execution. - Error Handling - AddMessage - AddWarning - AddError

Where the Geoprocessing of data is accomplished - Set output dataset to allow for chaining in ModelBuilder - SetOutputParameter

Model Builder

Model Builder

Allows for visual creation of Geoprocessing tools

- Consume custom geoprocessing tools
- Ensure you are setting an output!
- Export to Python code
- A good way to introduce scripting concepts

Advanced Python - Modular Design and Packages

Validation modules

For each validation requirement:

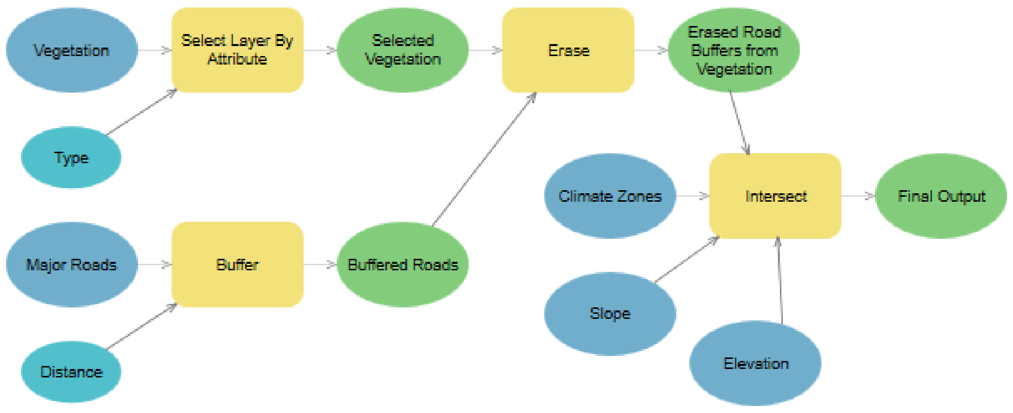


Figure 10:

- Create a function which will validate a dataset
- Create a dataset which satisfies the validation requirements
- Create one or more datasets which do not satisfy requirements
- Write validation functions

Debugging/Testing Tool Validation

Creating tests for validation:

- Validation accomplishes two things
- Ensuring the data set is ‘clean’
- Ensuring the data set will not crash the tool
- Two types of tests
- Correct data does not trigger any errors
- Incorrect data is error handled and returns a message

Planning the Logic of a Tool

For each requirement in a tool:

- Create a function which accomplishes the requirement statement

- Call the function from the applicable test method(s)
- Commit when the code passes the test(s)

Granularity in Tool Design

Can we break a tool into multiple tools?

- Does any requirement make sense as a standalone tool?
- Can we chain the tools together based off input/output parameters?
- Can these sub-tools be made more robust?
- Handle more data types
- Improve processing speed

Reusing Modular Code

Tool Metadata

- Tags
- Documentation

Conda Environments

Development Environments

Contains features in development

- May use alpha/beta code
- Contain test modules & data
- Mirrored by version control

Production Environments

Stable environments in which to run tools/services

- Ship reference to env with Project, Tool etc

- Requires stable versions of packages

Packaging Tools the Right Way

Creating a Package

Using setuptools and distutils to create a Python Package.

- setuptools
- setup
- pkg_resources
- distutils
- Legacy, use setuptools if possible

Creating a conda package

- bld.bat/bld.sh
- LICENSE
- Manifest.in
- meta.yaml
- README.md
- setup.py

Deploying a Package Internally

On a network - Point at a network location containing a package Via a http server - All advantages of any http service - Authentication - Metrics - Availability

Deploying a Package Publicly

Python Package Index Anaconda.org Custom Server

Viewing the Tool Output

Tools in ArcGIS Pro

Demonstration

- Geoprocessing History
- Stack-trace when tool fails
- Result File

Deploying a Tool as a Service

Tools and data sets can be uploaded to ArcGIS Enterprise or ArcGIS Online as services.

Demonstration

Consuming services via the ArcGIS Python API

The ArcGIS Python API is a cross-platform solution which allows for users to view, administer and interact with services on ArcGIS Enterprise or ArcGIS Online.

- More info to come tomorrow!

Thank you!! Questions/Comments?? cdow@esri.com