

ArcGIS API for Python

Experience ArcGIS in a Notebook



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gistec

SEE
WHAT
OTHERS
CAN'T

Agenda

- ArcGIS API for Python
- Jupyter Notebook / Lab
- Demo (Deep Learning / Palm Detection Using ArcGIS API for Python)
- ArcGIS Notebooks
- Quick tour of ArcGIS Notebooks
- ArcGIS Notebook Real Samples
- Questions & Answers

Python



Python is one of the most widely used programming languages. It is free, cross-platform, easy to learn and interpret, and can be applied to many disciplines.

Python was introduced to the ArcGIS community with ArcGIS 9.0.



ArcPy (Python 2.X)



ArcPy (Python 3.X)

Python + GIS use cases



Web GIS
Administration



Content
Management



Analysis and
Data Science

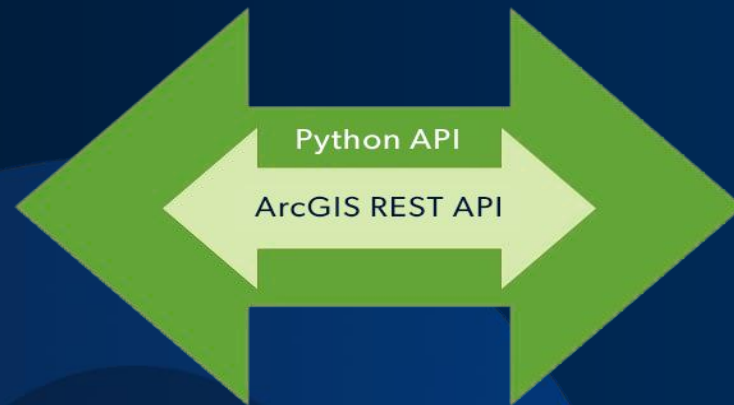
What is ArcGIS API for Python?

- Python library for spatial analysis, mapping and GIS
- Powerful, modern and easy to use
- Powered by Web GIS, with local capabilities

Made for AUTOMATION and DATA SCIENCE



Python Script



ArcGIS Server Site (RESTful)

ArcGIS API for Python and ArcPy

ArcPy

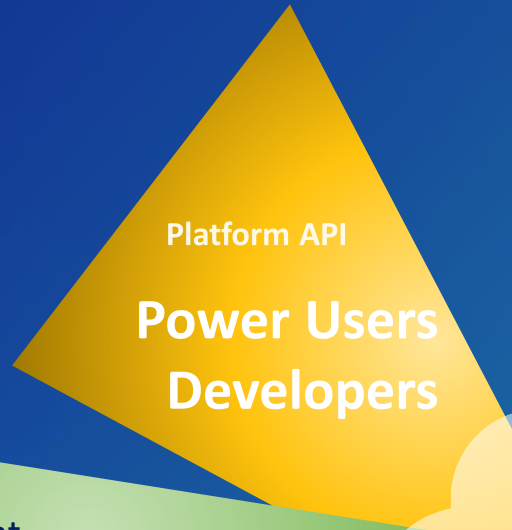
- ArcGIS Desktop
 - ArcMap – Python 2.x
 - ArcGIS Pro – 3.x
- Mostly geoprocessing
- Some map automation

ArcGIS API for Python

- Script against a portal
 - ArcGIS Online or ArcGIS Enterprise
 - Python 3.x
- Analysis, Portal Admin, Content Creation, Big Data Analysis

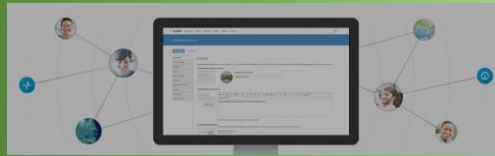
ArcGIS API for Python

- What can it do for you?



Enterprise Integration

Users, Roles & Group management

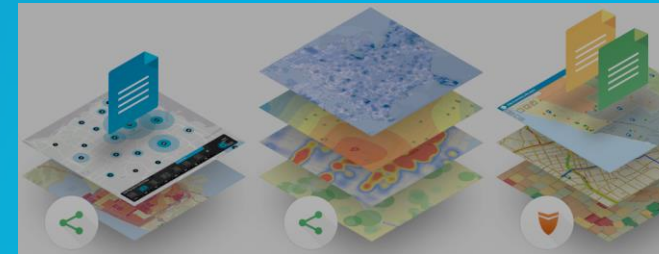


Administrators
DevOps



Your Web GIS

Content Publishers



Data Management

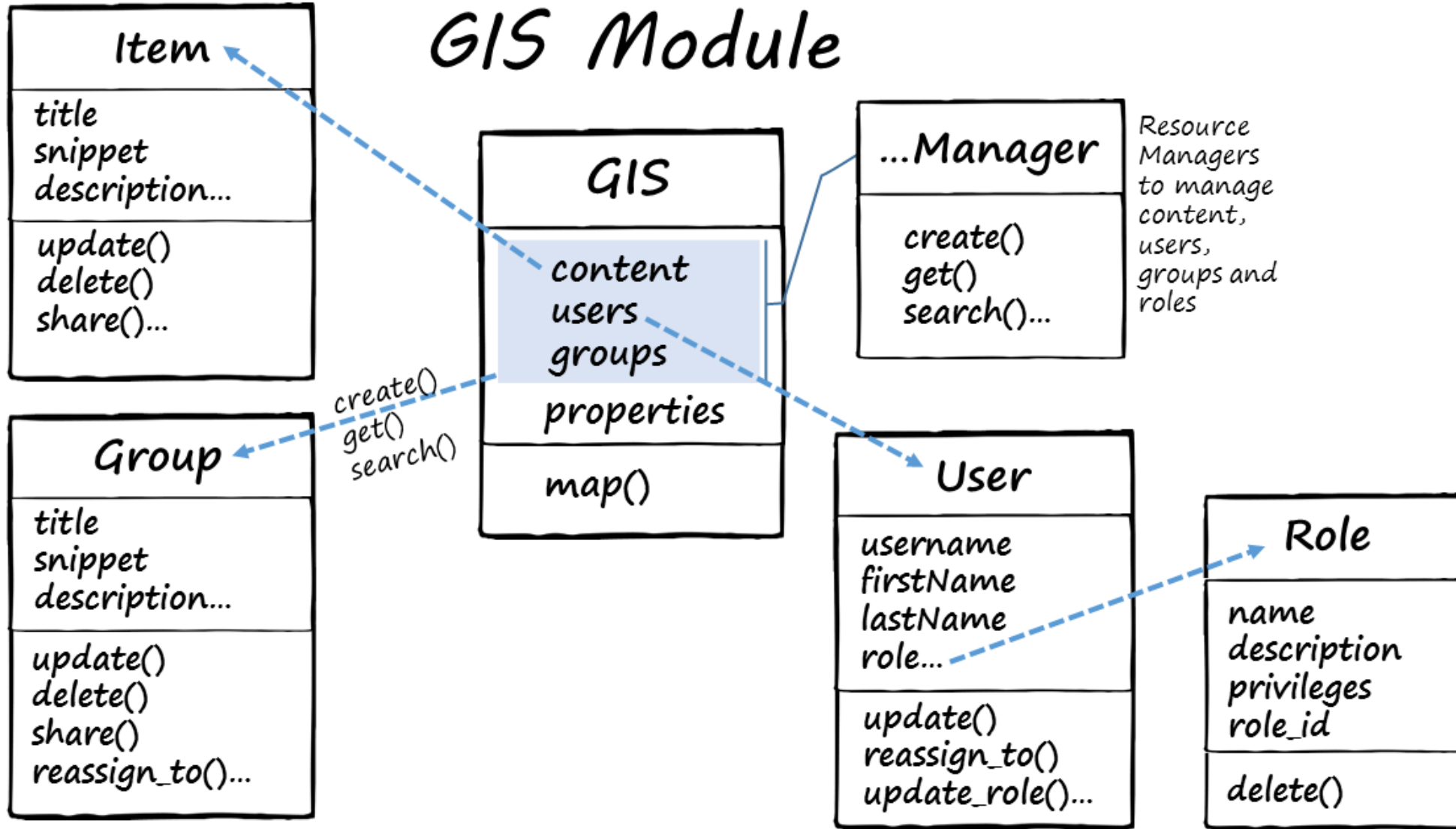
Script and automate your Web GIS

API Overview

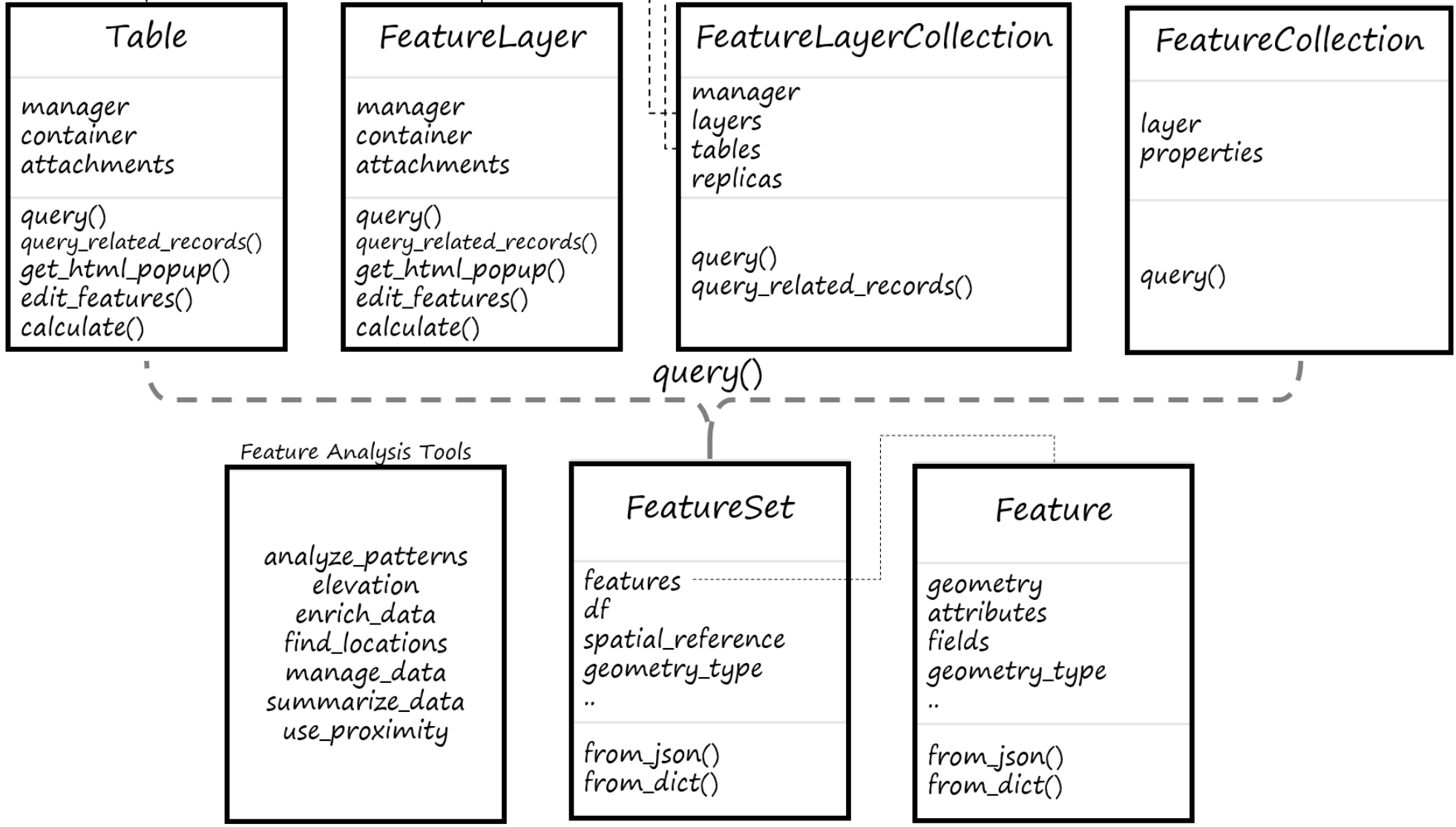
arcgis Package



GIS Module



features module



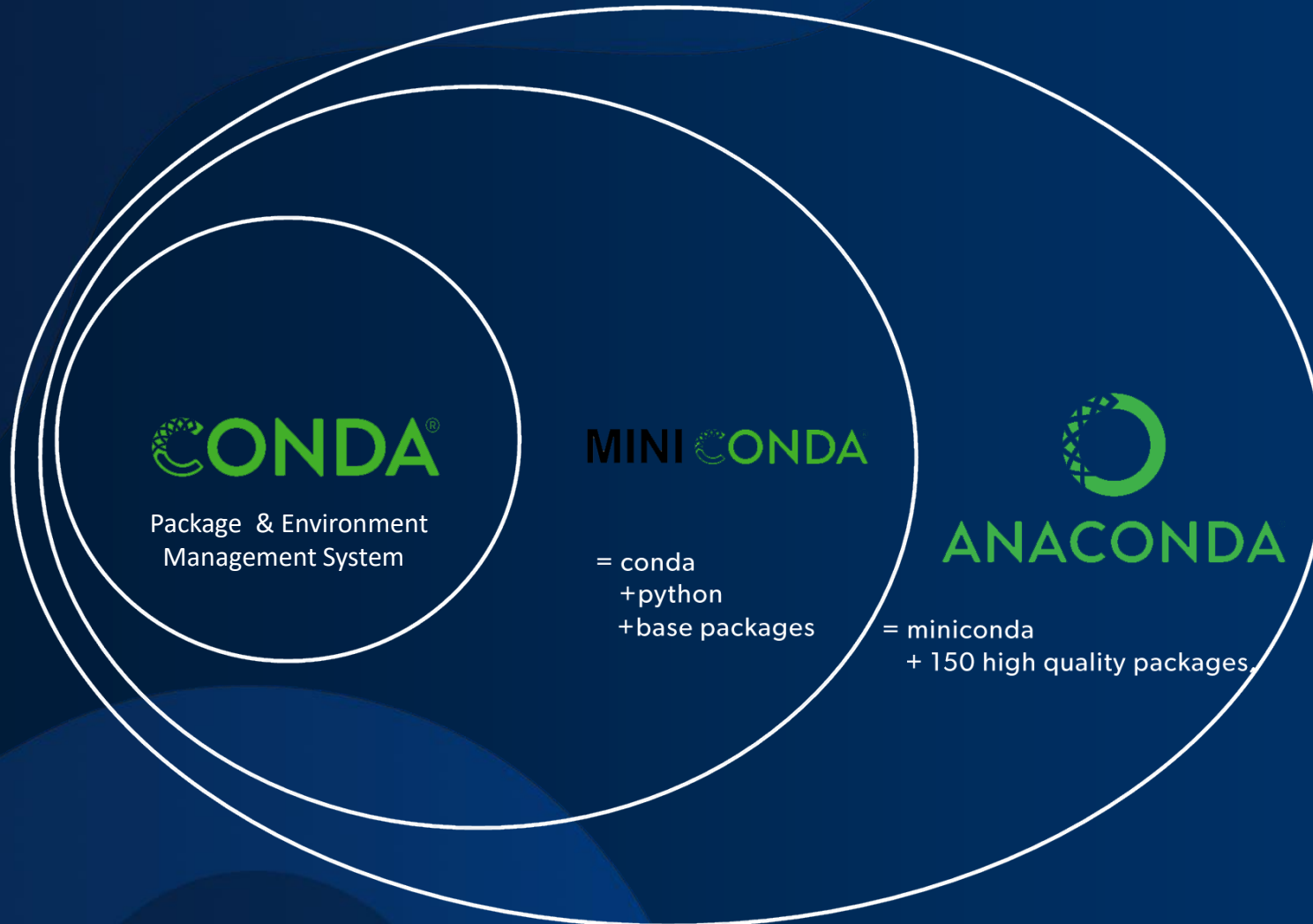
How do I get “ArcGIS API for Python”?

- Try it Live! – <https://notebooks.esri.com>
- ArcGIS Pro 2.1 and later – included
- pip install arcgis
- conda install -c esri arcgis
- docker pull esridocker/arcgis-api-python-notebook

For More Details:

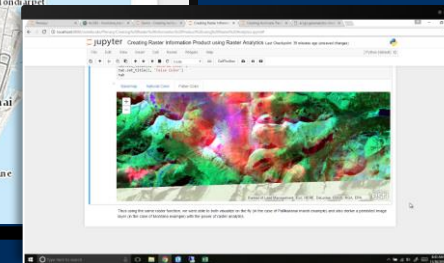
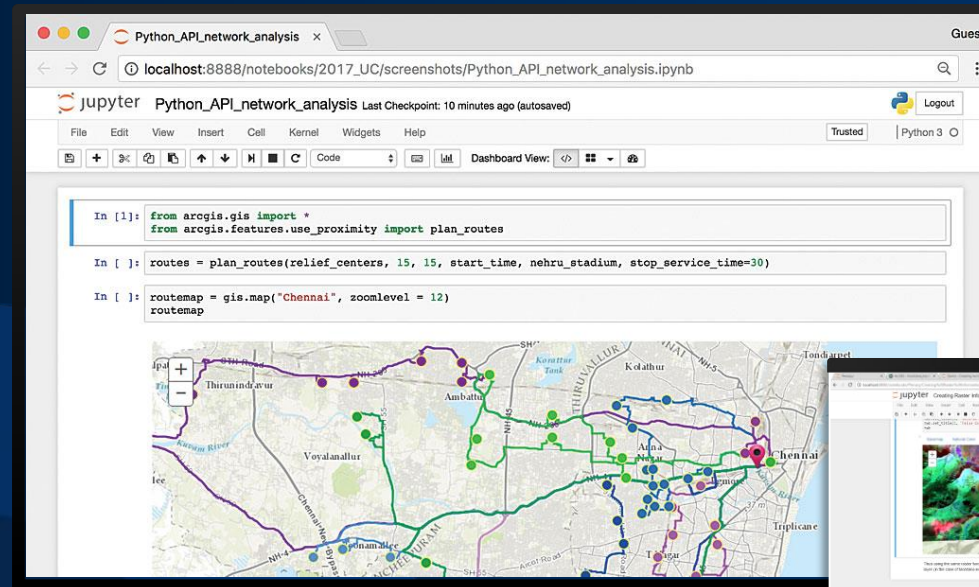
<https://developers.arcgis.com/python/guide/install-and-set-up/>

Differences between Conda, MiniConda, and Anaconda



Python Jupyter Notebook

- It is a web-based, interactive, computational environment for you to write, document, and run code all in one place.
- Jupyter is a popular open source notebook environment
 - Jupyter gets its name from three programming languages: Julia, Python, and R
- The ArcGIS API for Python was developed to make the most of Jupyter's functionality.



ArcGIS + Jupyter = ❤️

esri | THE SCIENCE OF WHERE™ | chennai_floods_analysis (autosaved) | Python 3

```
df.head()
```

WEATHER STATION	LOCATION	RAINFALL
0	TAMBARAM, TAMIL NADU	49
1	CHEMBARABAKKAM, TAMIL NADU	47
2	MARAKKANAM, TAMIL NADU	42
3	CHENGALPATTU, TAMIL NADU	39
4	PONNERI, TAMIL NADU	39

Tabular data is hard to visualize, so let's bring in a map from our GIS to visualize the data:

```
In [67]: # Create a map of Pittsburgh to show hot spot outputs
hot_spots_map = gis.map("Pittsburgh")
hot_spots_map.add_layer(restaurant_hot_spots_item)
hot_spots_map.zoom = 10
hot_spots_map
```

Out[67]:

County of Allegheny, West Virginia GIS. Esri, HERE, Garmin, USGS, EPA, USA, NPS | Powered by Esri

jupyter | 2017 Southern California Wildfires analysis | Last Checkpoint: 12/22/2017 (unsaved changes) | Python [default]

```
In [81]: map = gis.map("Chennai")
map
```

Out[81]:

Esri, HERE, Garmin, FAO, NOAA, USGS | Powered by Esri

We can search for content in our GIS and add layers to our map that can be used for visualization or analysis:

Age Pyramid of affected population

```
In [23]: print('Number of affected people: ' + str(popdf['female'].sum() - popdf['male'].sum()))
Number of affected people: 11226
```

```
In [24]: sns.barplot(x="female", y="age", color="#CC6699", label="Female", data=popdf, edgecolor='none')
sns.barplot(x="male", y="age", color="#008A88", label="Male", data=popdf, edgecolor='none')
plt.ylabel('Age group')
plt.xlabel('Number of people');
```

Age group: 85-89, 80-84, 75-79, 70-74, 65-69, 60-64, 55-59, 50-54, 45-49, 40-44, 35-39, 30-34, 25-29, 20-24, 15-19, 10-14, 5-9, 0-4

Number of people: -400, -200, 0, 200, 400

Demo

Palm Detection using Deep Learning In Jupyter Notebook/Lab

A screenshot of a Jupyter Notebook interface. The interface is divided into three main sections: a file browser on the left, a code editor in the center, and an ArcGIS Map on the right. The file browser shows a directory structure with files like 'conda-meta', 'DLLs', 'etc', 'include', 'Lib', 'Lib', 'libs', 'man', 'Menu', 'Scripts', 'share', 'tcl', 'Tools', 'Notebook Test Caes.i...', 'Tests Cases.ipynb', 'Tests Notebook.ipynb', 'Untitled.ipynb', 'Untitled1.ipynb', 'Untitled2.ipynb', and 'Untitled3.ipynb'. The code editor shows the following code:

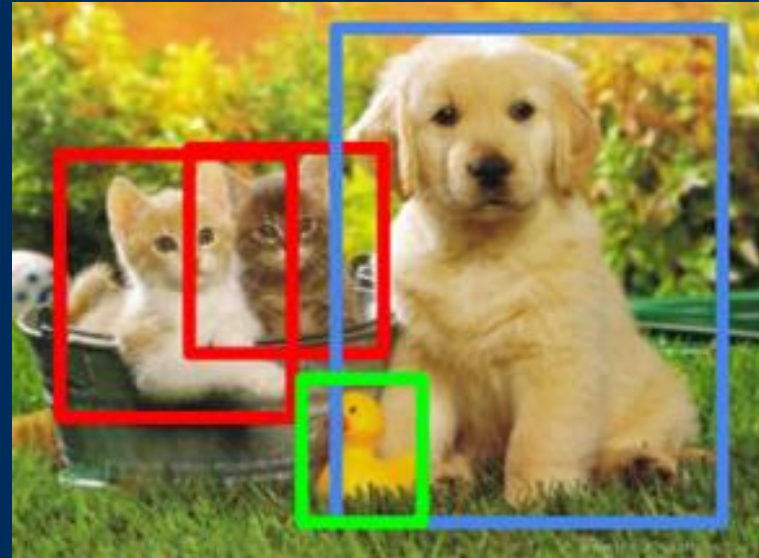
```
[1]: from arcgis.gis import GIS
[2]: gis = GIS()
[5]: map = gis.map()
[6]: map
[7]: gis = GIS('http://geo-demos-1.gistec.com/portal', '
Enter password: .....
[14]: from datetime import datetime
def whatiscurrentdate():
    now = datetime.now()
    dt_string = now.strftime('%d/%m/%Y %H:%M:%S')
    print('Current Date: ',dt_string)
[13]: whatiscurrentdate()
Current Date: 10/01/2020 16:20:30
[15]: whatiscurrentdate()
Current Date: 10/01/2020 16:20:45
```

The ArcGIS Map on the right shows a map of the Middle East region, including Sharjah, Dubai, and Abu Dhabi. The map is titled 'ArcGIS Map' and has a toolbar with zoom in, zoom out, and pan icons.

Image Classification vs Object Detection



Image Classification



Object Detection

Deep Learning Palm Detection Input



Tanga / Kolovai

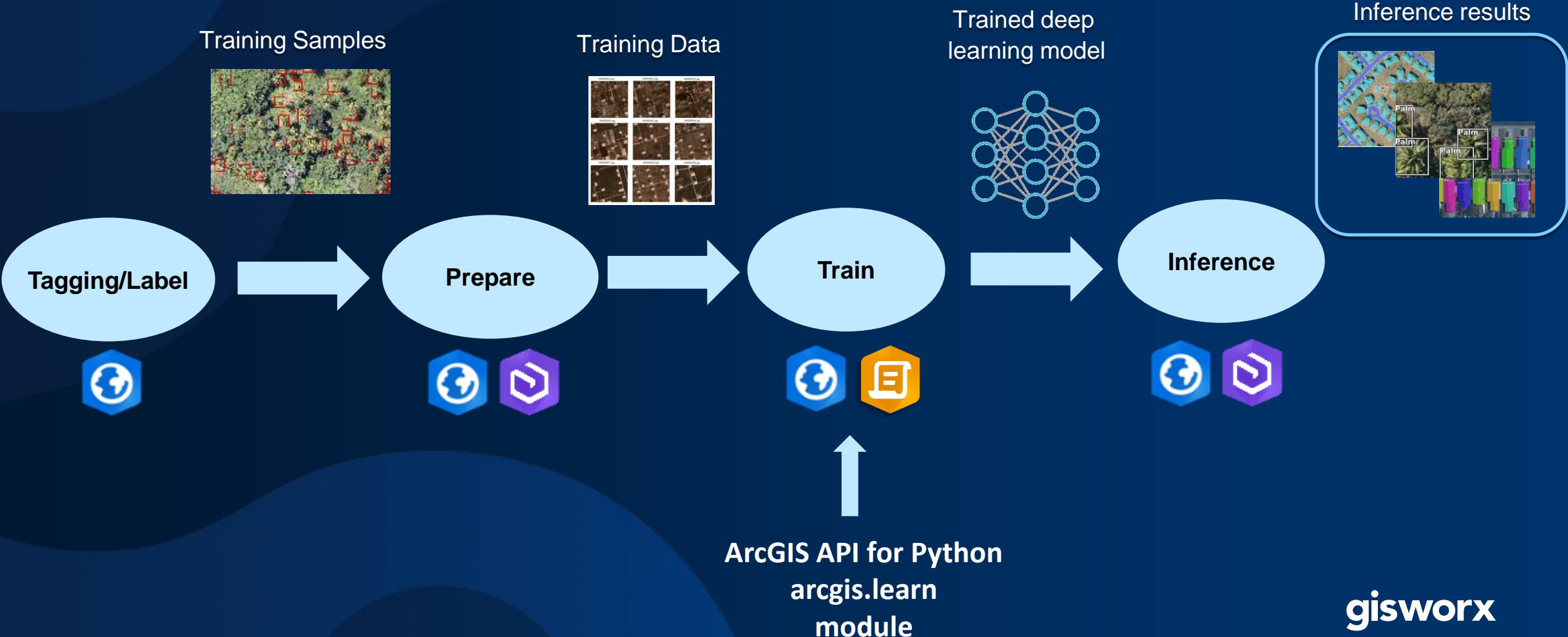
Deep Learning Palm Detection Output



Deep Learning
Palm Detection
Feature To Point



Deep Learning / Object Detection Workflow in ArcGIS



ArcGIS Notebooks



Introduction

What is ArcGIS Notebooks?

A new capability that lets you create hosted Python notebooks using a Jupyter scripting environment that has been built into ArcGIS.

In 2020, ArcGIS Notebooks will be available in...



ArcGIS
Enterprise



ArcGIS
Pro



ArcGIS
Online

ArcGIS Notebooks sits at the intersection of ArcGIS and open data science

- ArcGIS API for Python
- ArcPy
- Analytics
 - Geoprocessing
 - Web GIS analysis
 - GeoAnalytics
 - Raster Analytics

ArcGIS



Open Source

Python & Data Science



Demo

Quick tour of ArcGIS Notebooks

A screenshot of an ArcGIS Notebook interface. The browser address bar shows "ArcGIS | Walkability Study: Los Angeles". The interface includes a "My Content" sidebar on the left with a search bar and a list of layers such as "Heart Disease Prevalence - Adults", "Walkability Index", "Hospitals and Medical Centers", "Red Cross Offices", "Safe Havens", "Medicare and Medicaid Offices", and "Health and Housing Inspections". The main area contains a code editor with Python code for importing data and creating a heatmap. Below the code, a "Walkability Index" feature layer is displayed with a thumbnail map. At the bottom, a table of data is shown, followed by a map visualization of the Los Angeles area with a heatmap overlay.

```
import pandas as pd
import os
import arcpy
import sklearn

from arcpy.mapping import addlayer
from arcpy.gx import Import_GIS
gx = GX("name")

# Item Added From Toolbox
# Title: Walkability Index / Type: Feature Service / Owner: sbalisky
walkability = gis.content.get("5a6d996e3a4976364e3646d237")
walkability

walkability

df = walkability.layers[0].query(ex_where="True")
df.head()

GEOID10 GEOID11 int_2 int_start LIDV_2 LI_3View OBJECTID Row_Den Row_2 Row_Den Row_2
0 9002709010 9002709010 -1.571469 36.860000 -0.900000 0.280000 1 20.712546 -0.150316 0.022002 -0.437202 (7969) (20427891 0000107, 190074 020004, 81700010 -0.140215 -0.302770)
1 9002709040 9002709040 -0.022012 142.840000 0.101000 0.403000 2 7.000719 -0.403020 0.000047 -0.422240 (7969) (20422891 49000720, 1940000 124000, 20440150 -1.910014 -0.200100)
2 9002709010 9002709010 -1.140021 90.070000 -0.091000 0.410000 3 0.020001 -0.401040 0.000000 -0.000047 (7969) (20422891 49000720, 1940000 124000, 21120707 -0.391019 -0.200100)
3 9002709020 9002709020 -0.000004 110.070000 -1.020470 0.234012 4 4.970007 -0.402770 0.000000 -0.000047 (7969) (20440121 0000100, 1940000 000000, 21220403 -4.152200 -0.201100)
4 9002709010 9002709011 -1.310070 01.430400 -0.190020 0.401000 5 4.172000 -0.407400 0.000000 -0.000047 (7969) (20440121 0000100, 1940000 000000, 47102007 -0.020410 -0.210400)
```

```
m = gis.map("Los Angeles")
m.background = "dark:gray"
m.add_layer(walkability)
m
```

How is ArcGIS Notebooks different than “traditional” Jupyter?

- Built within ArcGIS rather than sitting beside it
- Leverages an integrated UI
 - Automatically insert Python snippets
 - Quickly access a gallery of samples
- Notebooks as items
- Use ArcPy without ArcGIS Pro
- Centrally manage libraries and packages



Python != Notebooks

Programming language.

There are many ways to write and execute Python code.

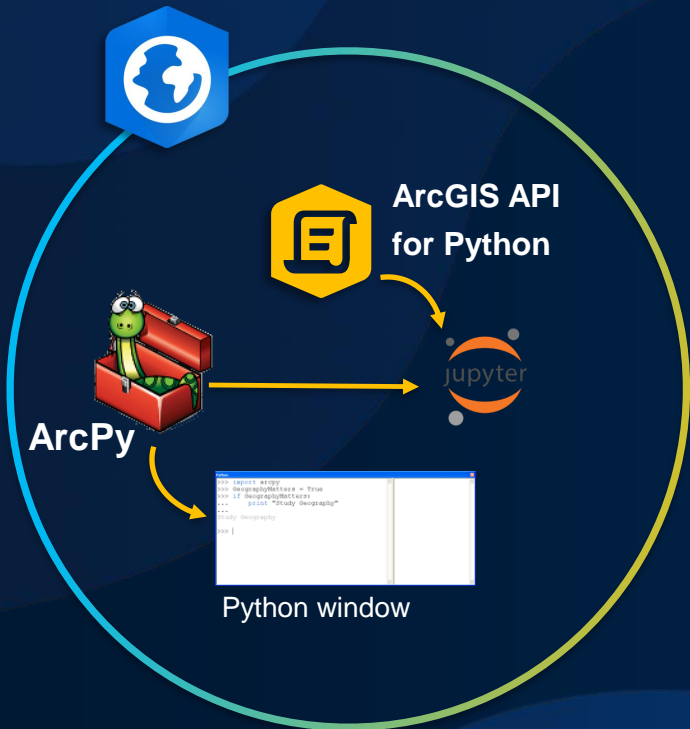


Computational environment.

Could be used with other programming languages.

Why do we talk about Python and notebooks together?

ArcGIS Pro



ArcGIS API for Python



ArcGIS Notebooks



User managed Jupyter

Integrated experience
within the Web GIS
gisworx

What does ArcGIS Notebooks provide?

- **Ready-to-use scripting libraries**
 - ArcGIS API for Python
 - Mathematical, statistical, and machine learning libraries
 - ArcPy
 - Python libraries and packages are synchronized across the organization
- **A gallery of curated notebook samples**
 - Samples generated by Esri data scientists, engineers, and analytical teams
 - Notebook samples are end-to-end workflows that include all necessary datasets
 - Administrative notebook samples included
- **One-click access to a new notebook**
- **Seamless integration with the Web GIS interface**
 - Access to data and analysis tools in your Web GIS, collaborate and share
- **Secure identity-based access**
 - Read-only previews of notebooks

How do notebooks help people solve problems?

- **They tell a story**
 - **Promote transparency and reproducibility**
 - **Help turn analysis into action**
- **They allow you to iterate and get feedback quickly because they are interactive**
- **Help people create more effective models by using spatial data and analysis tools**
- **Integration with ArcGIS, to promote collaboration and sharing**

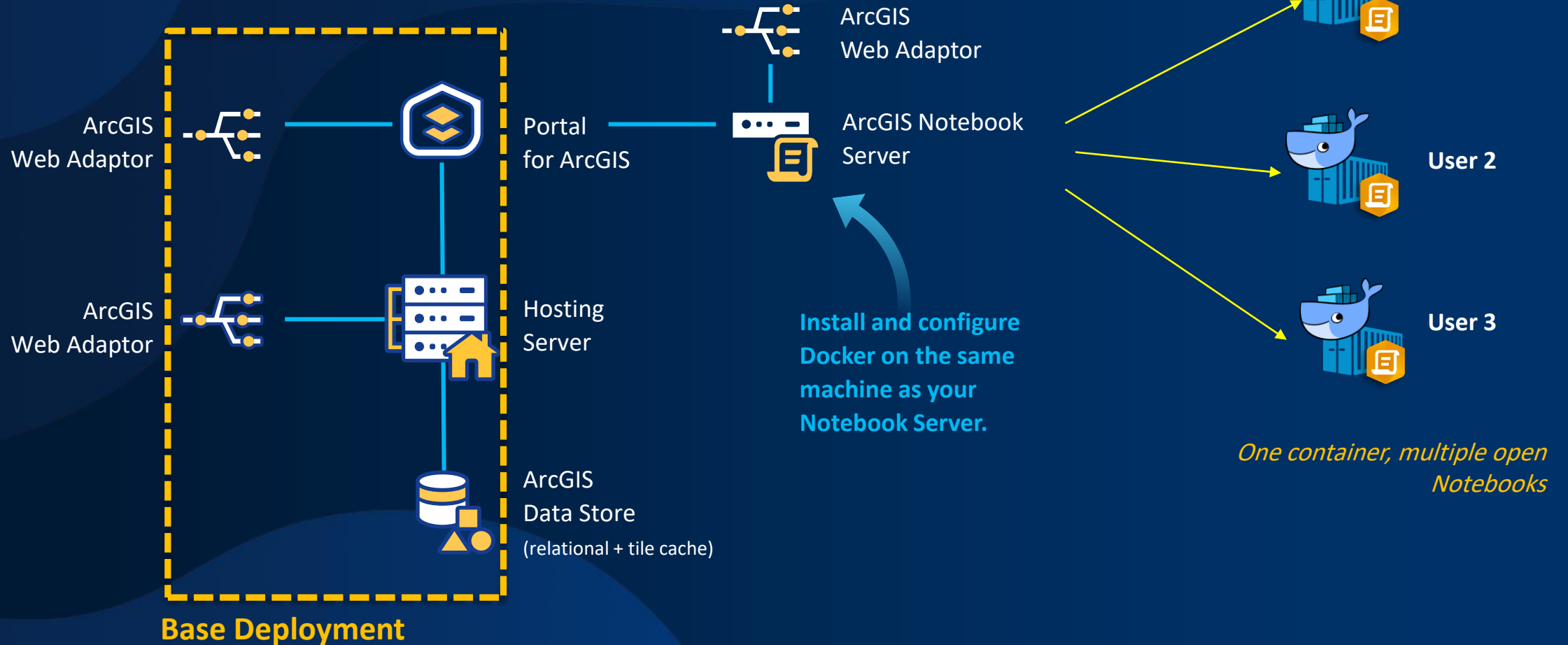
Essential knowledge

Images and containers

Terminology - Docker

- Docker is a tool designed to make it easier to create, deploy, and run applications by using containers.
- Container – A virtualized workspace that packages up all the code and dependencies a user needs to run the application.
 - Not a VM
 - Virtual machines virtualize hardware
 - Containers virtualize the OS
- Image – Instructions for Docker on how to setup the container.
 - ArcGIS Notebook Server includes two images:
 - ArcGIS Notebook Server Standard
 - ArcGIS Notebook Server Advanced
 - Customers have the option of creating their own custom images to use with ArcGIS Notebook Server
 - Within the product we refer to the Docker images as notebook runtimes
- Within ArcGIS Notebook Server, each user gets one container per notebook runtime they have access to.

Conceptual Architecture



Why do we use Docker?

- Security
- Code isolation

Who can create and run notebooks?

- Administrators
- Non-administrators will require a custom role
- These are the only people who will see the Notebook option in the top ribbon of the portal

- Minimum user type is a Creator

- If a notebook is shared with someone who does not have privileges to create and run notebooks they will only be able to:
 - View the notebook's item details page
 - Preview the notebook
 - Download the notebook

Sample notebooks



Deep Learning: Detect swimming pools, part 1

Notebook by [esri_notebook](#)

Export training data for object detection.

Created: Jan 28, 2019 Updated: Jan 28, 2019 View Count: 0

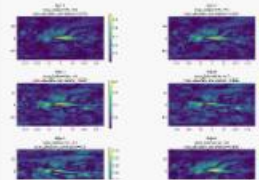


Deep Learning: Downscale climate models

Notebook by [esri_notebook](#)

Harness ArcGIS platform's internal machine learning libraries and strong extensibility to external machine learning libraries to downscale climate models

Created: Jan 28, 2019 Updated: Jan 28, 2019 View Count: 0



Deep Learning: Predict El Niño-southern oscillation

Notebook by [esri_notebook](#)

This example uses correlation analysis and time series analysis to predict El Niño-Southern Oscillation (ENSO) based on climate variables and indices.

Created: Jan 28, 2019 Updated: Jan 28, 2019 View Count: 0



EBK Regression: Identify urban heat islands

Notebook by [esri_notebook](#)

Interpolate temperature measurements to identify city areas with high temperatures and high density of residents.

Created: Jan 28, 2019 Updated: Jan 28, 2019 View Count: 0



Exploratory Statistics: Hurricane analysis, part 2/3

Notebook by [esri_notebook](#)

Perform exploratory data analysis on hurricane tracks.

Created: Jan 28, 2019 Updated: Jan 28, 2019 View Count: 0



Forest-based Classification: Predict asthma rates

Notebook by [esri_notebook](#)

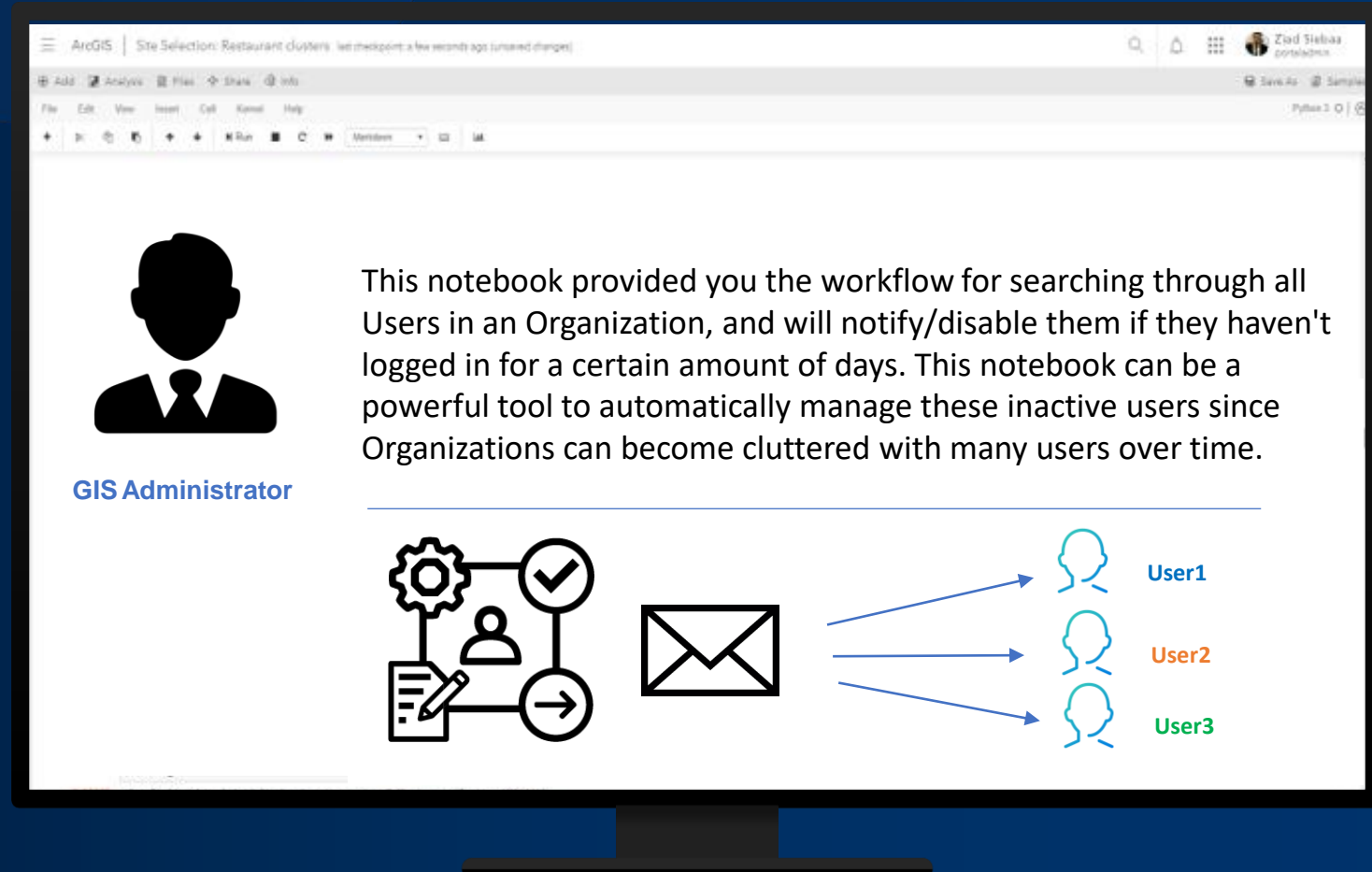
Determine what census block groups in Connecticut have the highest children's hospitalization rates for asthma related

Samples

- Types of samples:
 - Data science and analysis
 - Content management
 - Administration
- Some notebooks are ready-to-run, others require additional configuration
- Notebook samples that use ArcPy require Advanced privileges
- Some samples require utility services
- Data is included and available for all notebooks

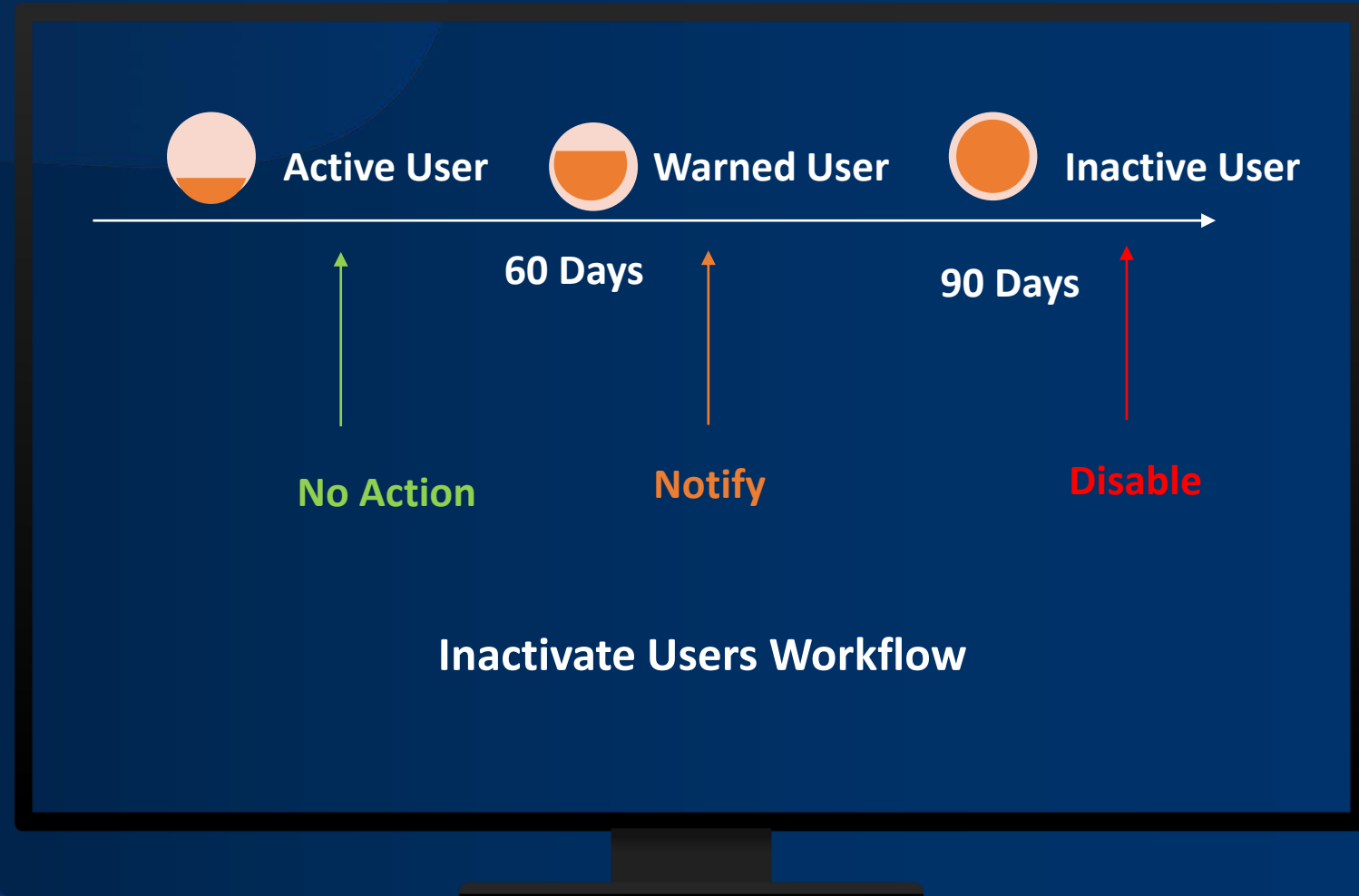
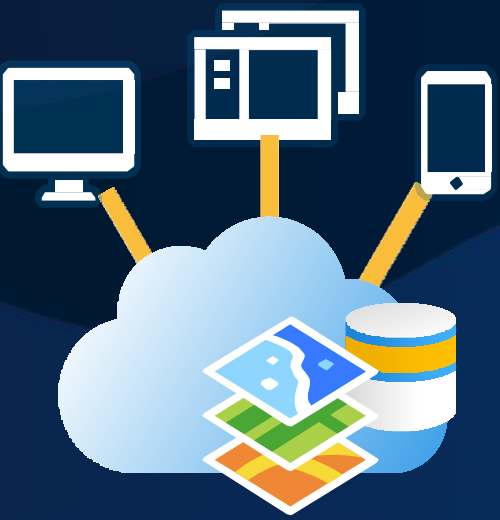
Sample #1

Administration: Manage inactive users



Sample #1

Administration: Manage inactive users



Sample #2

Data Science: Site Selection /
Restaurant clusters



ArcGIS | Site Selection: Restaurant clusters | last checkpoint: a few seconds ago (unsaved changes)

File Edit View Insert Cell Kernel Help

3) Perform spatial analysis

To help us identify potential sites for further analysis, we will average spatial clustering to 1

Density-based Clustering

• Cluster 1
• Cluster 2
• Cluster 3
• Noise

The **Density-based Clustering tool** works by detecting areas where points are concentrated. This tool uses unsupervised machine learning clustering algorithms which automatically do as what it means to be a cluster.

Three clustering algorithms:

The Density-based Clustering tool provides three different Clustering Methods with which it

- **Defined distance (DBSCAN)** — Uses a specified distance to separate dense clusters from clusters. This requires that all meaningful clusters have similar densities.
- **Self-adjusting (ADBSKAN)** — Uses a range of distances to separate clusters of varying
- **Multi-scale (OPTICS)** — Uses the distance between neighboring features to create a hierarchical structure. It is computationally intensive, particularly with a large Search Distance.

```
In [32]: # Set an output path name
output_path = "{0}/{1}_DBSCAN".format(rgb, "RestaurantClusters")
clusters_fc = arcpy.stats.DensityBasedClustering(fc, output_path,
"DBSCAN", 1)
clusters_fc
```

The map displays the Pittsburgh area with various landmarks and roads. The restaurant clusters are represented by colored dots: blue for Cluster 1, green for Cluster 2, orange for Cluster 3, and grey for Noise. The clusters are concentrated in the downtown area and surrounding suburbs.

Deployment, Setup and Licensing

Images and containers

ArcGIS Notebooks

- In ArcGIS Enterprise at 10.7 we talk about ArcGIS Notebook Server
 - Server licensing role
 - 2 levels: Standard and Advanced
- In ArcGIS Online 2020 we talk about ArcGIS Notebooks
 - There is no server or infrastructure for the customer to setup
 - More details to be announced later this year

What's the difference between Standard and Advanced → ArcPy!



ArcGIS API for Python + 3rd
party Python libraries
(over 175 Library)



Standard + ArcPy libraries

gisworx

Note: Don't let the names fool you

- The terms Standard and Advanced only denote functionality differences relative to the specific server role.
- ArcGIS Enterprise Standard or Advanced is a prerequisite, however:
 - An ArcGIS Enterprise Standard customer could choose to purchase ArcGIS Notebook Server Advanced
 - An ArcGIS Enterprise Advanced customer could choose to only use ArcGIS Notebook Server Standard

System Requirements

Prerequisites

Windows

- HyperV
- Docker Desktop
 - Docker must use Linux containers

Linux

- Docker
 - The specific version of Docker will depend on the OS selected

Hardware Requirements

- 8 GB RAM
- 50 GB disk space

- 8 GB RAM
- 50 GB on /var directory

Operating Systems

- Window Server 2016 (Standard or higher)
- Windows Server 2019

- Red Hat Enterprise Linux Server 7
- Ubuntu LTS Server 16.04 or 18.04

Browsers

- Chrome
- Firefox
- Edge

- Chrome
- Firefox
- Edge

Resources

- Website : <https://developers.arcgis.com/python/>
- GitHub repo : <https://github.com/Esri/arcgis-python-api>
- Try it Live! : <https://notebooks.esri.com>
- API Reference : <https://esri.github.io/arcgis-python-api/apidoc/html/>
- Community : <https://community.esri.com/groups/arcgis-python-api/>
- Documentation : <https://developers.arcgis.com/python/api-reference/index.html>
- Object Detection : <https://learn.arcgis.com/en/projects/use-deep-learning-to-assess-palm-tree-health/>



Thank you!

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