ISAHP 2024 WORKSHOP 1

Mastering AHP Models in Python: Setup, Calculation, and Sensitivity Analysis with AhpAnpLib

Lirong Wei

2024.12

CREATIVE DECISIONS FOUNDATION

- Goal:
  - ✓Setup the environment to use AnpAnpLib python library
  - ✓Learn how to use AhpAnpLib

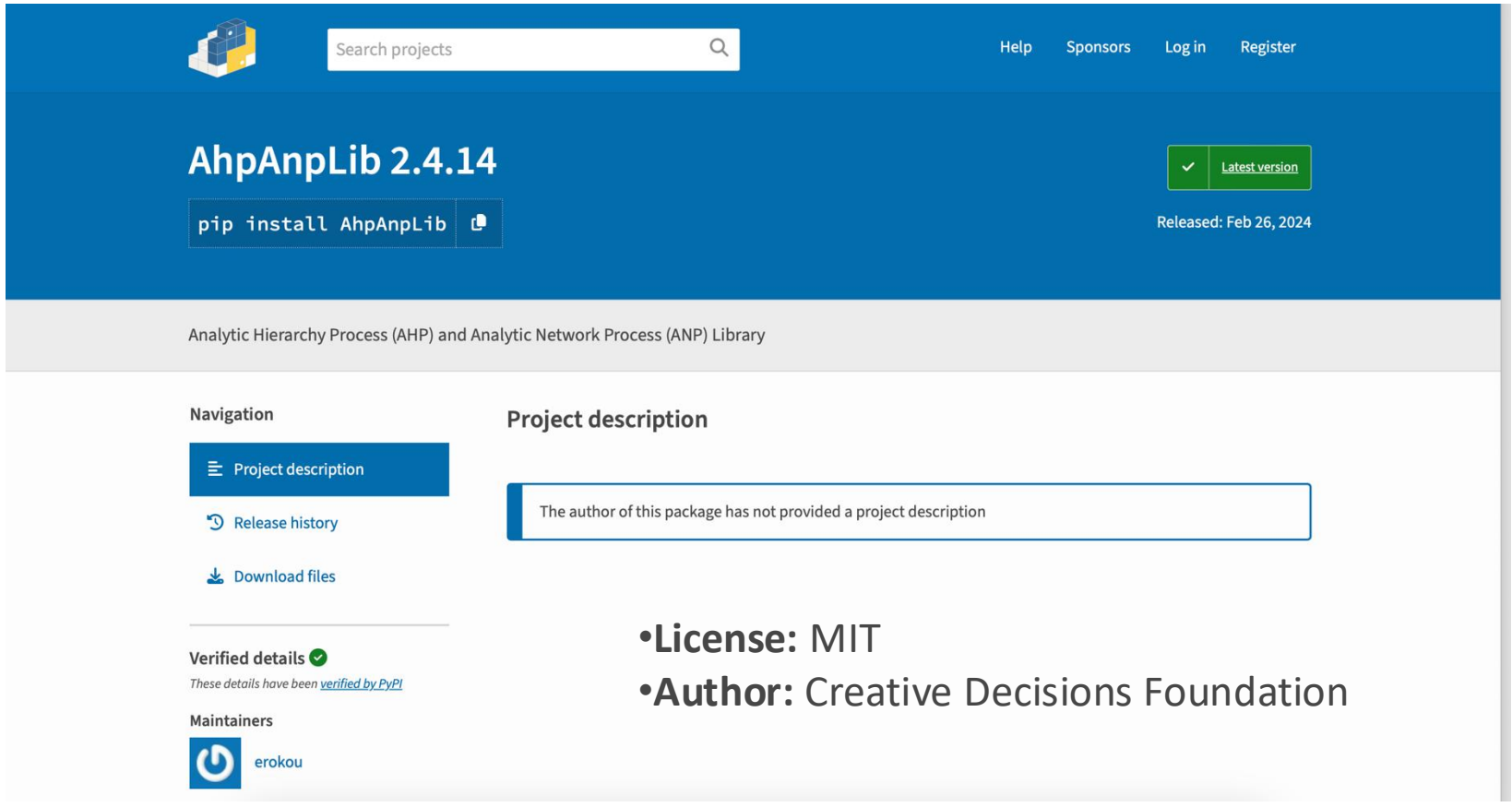
- What will be covered?
  - How to use AhpAnpLib in **Google Colab**? (setting up the environment)
  - How to structure **an AHP model in Excel**?
  - How to import model from Excel using Python?
  - How to conduct basic **sensitivity analysis** using AhpAnpLib?
  - ❑How to repurpose **SuperDecisions** model in Python?

- Q&A / Troubleshooting

WHAT IS AHPANPLIB?

- **AhpAnpLib:** a **Python** library developed by CDF to assist in the process of structuring models using the **Analytic Hierarchy Process/Analytic Network Process**.

https://pypi.org/project/AhpAnpLib/



SETTING UP THE ENVIRONMENT

- Open **Google Colab** in your browser 

  https://colab.research.google.com/

- Ensure you are **signed in** with your Google account

STRUCTURING AN AHP MODEL WITH EXCEL

OptiCorp is a **mid-sized technology consulting firm** specializing in business optimization solutions through custom software and AI tools.

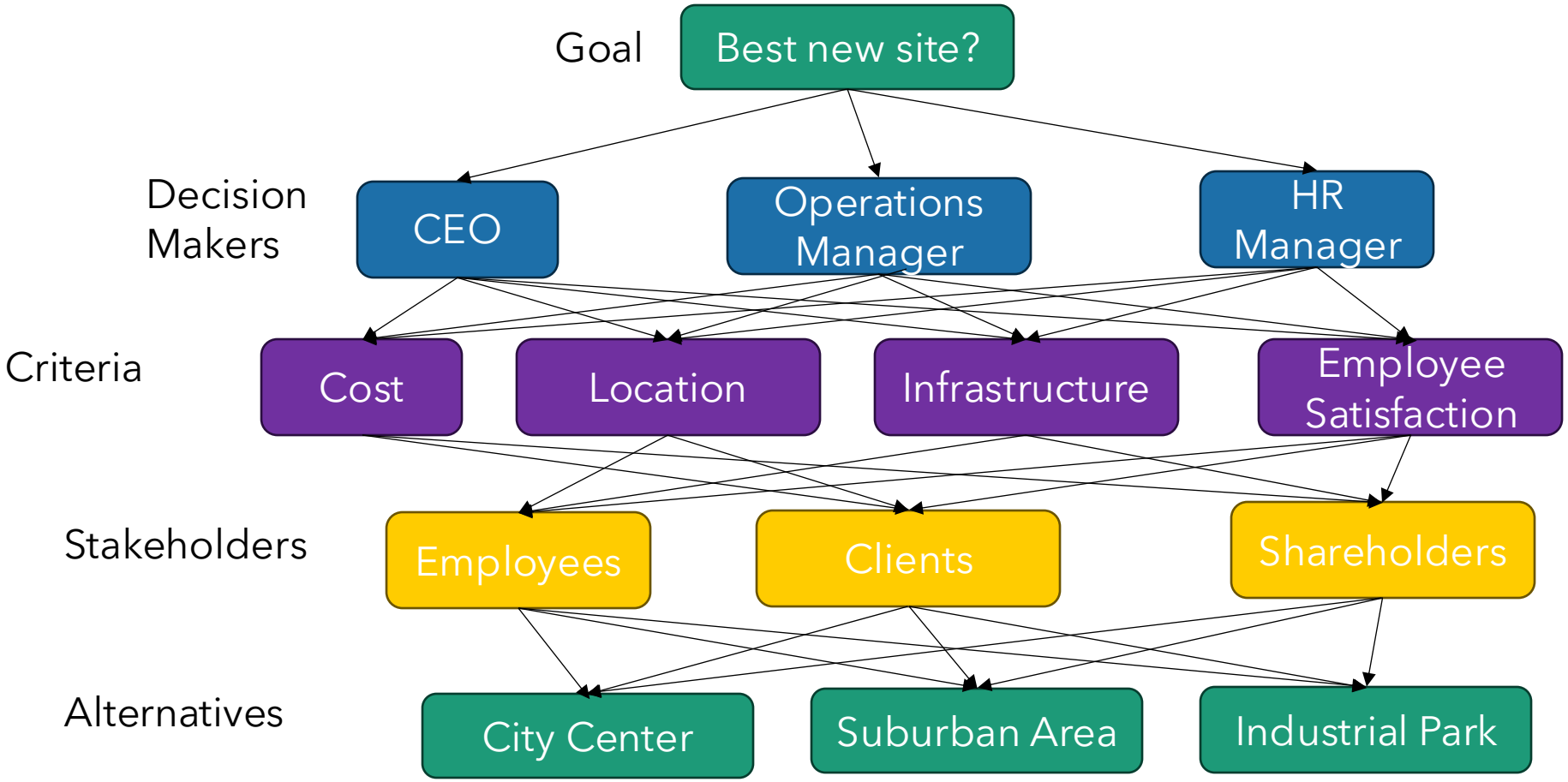
The company has been expanding rapidly, and with its current lease ending, OptiCorp is in the process of selecting a new office location to accommodate its growth and improve its operational efficiency.

OptiCorp's employee base is highly skilled, with many employees working on-site and others needing a flexible workspace due to remote and hybrid work arrangements.

Office Location Alternatives:

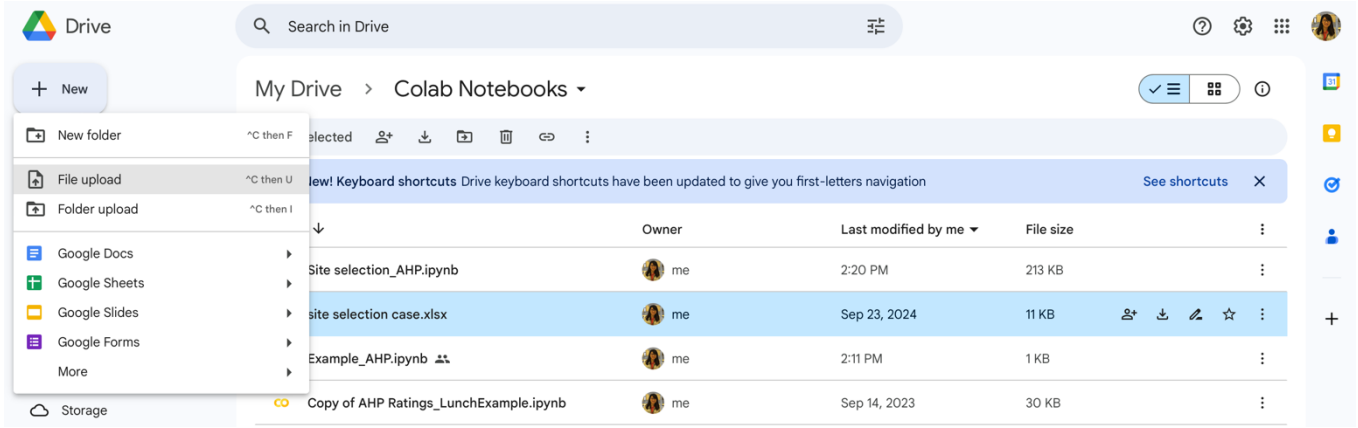
Location A	Location B	Location C
• Downtown Metro (City Center)	• Suburban Business Park	• Industrial Park

STRUCTURING AN AHP MODEL WITH EXCEL

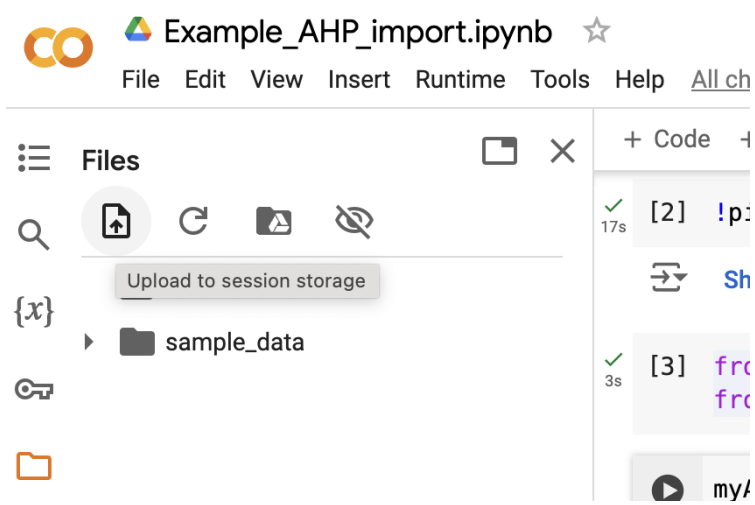


IMPORTING MODEL FROM EXCEL USING PYTHON

- **1. Uploading the Excel file to Google Drive**



- **Or Uploading the Excel file to Google Colab server temporally**



- **2. Read structure from excel to python**

New Code Cell

```
from google.colab import drive
drive.mount('/content/drive', force_remount=True)

#read structure from Excel
input.readStructFromExcel(location,"/content/drive/My Drive/Colab Notebooks/site selection
case.xlsx","structure",False)
#read connections from Excel
input.readConnectionsFromExcel(location,"/content/drive/My Drive/Colab Notebooks/site selection
case.xlsx","connection",False)
```

Model variable

Excel file name

verb: whether to display the import details
– "False": no details will be displayed

Sheet name in the Excel that has the model structure/node connections

- **3. Generate a questionnaire to collect judgments**

Generate Excel questionnaire

New Code Cell

```
#print model structure
location.printStruct()

#export excel questionnaire
input.export4ExcelQuestFull(location,"/content/drive/My Drive/Colab Notebooks/AHP_Site_selection_Excel_questionnaire_empty.xlsx",True)
```

model variable

Questionnaire file path and name

show_estimates ? include a column for each pairwise comparison matrix with an estimate of the priorities?

True: include the estimated priorities column
False: do not include it
By default, it is False if the parameter is omitted in the command

HR Manager

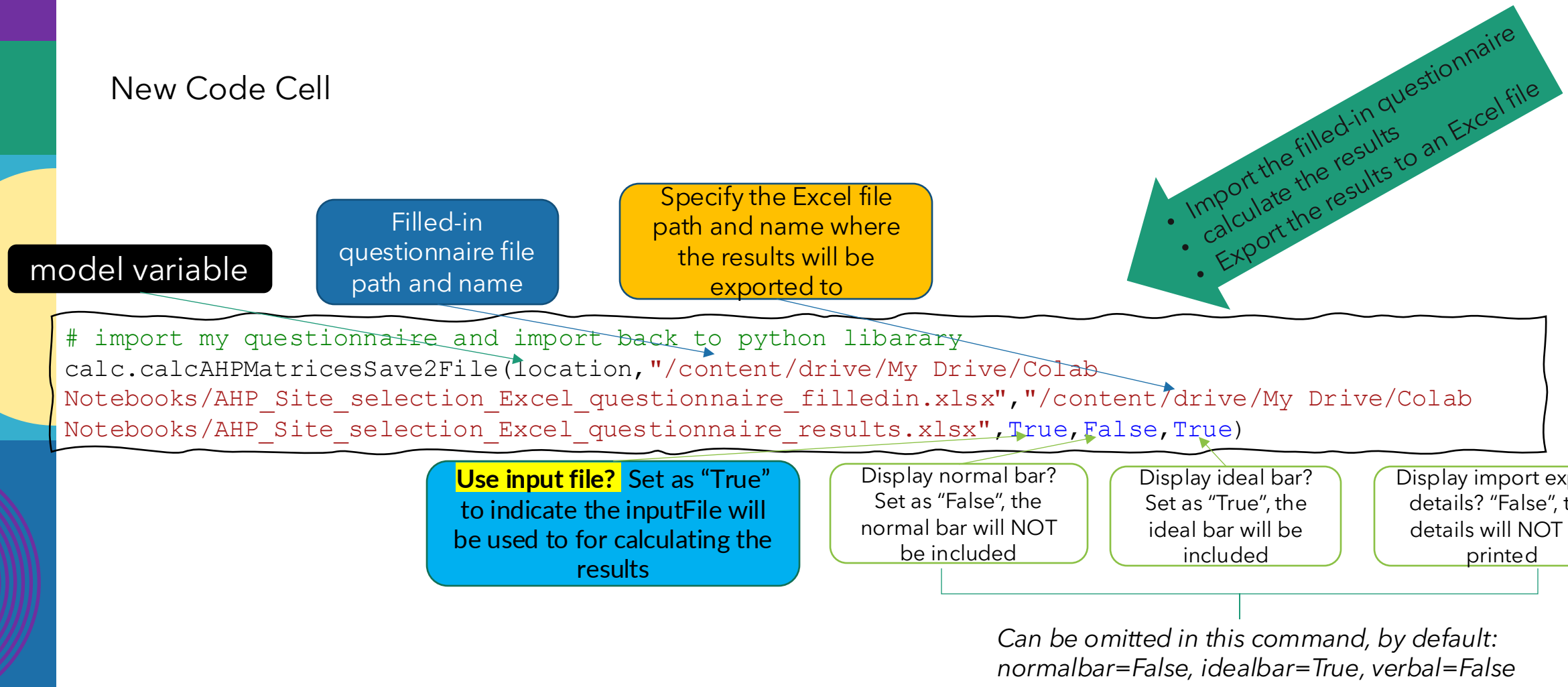
Enter pairwise comparisons in the white cells of the table or numerical data in the green cells. For the Direct Values column, if the smallest value is best, invert the valu

Criteria	Cost	Location	Infrastructure	Employee Satisfacti	Direct values	Line Sum	Estimated Priority
Cost	1	0.5	0.5	0.142857143		2.14	0.07
Location	2	1	1	0.2		4.20	0.14
Infrastructure	2	1	1	0.142857143		4.14	0.14
Employee Satisfacti	7	5	7	1		20.00	0.66
Sum of Col	12.00	7.50	9.50	1.49		30.49	
						Est. Incons.	0.05

Cost

- **5. Use filled-in excel questionnaire to calculate the results**

New Code Cell



PERFORMING SENSITIVITY ANALYSIS

New Code Cell

model variable

Cluster name holding the alternatives

Specify the Excel file path and name for exporting the results.
We use the same file as the AHP model results, so the new data will be appended to that Excel file.

```
#sensitivity analysis
calc.sensitivityCellSupermatrixPlot(location,"Alternatives","/content/drive/My Drive/Colab Notebooks/AHP_Site_selection_Excel_questionnaire_results.xlsx",False,"Cost","Location","Infrastructure","Employee Satisfaction")
```

verb: whether to display the calculation details – “False”: no details will be displayed

Specify the node names to analyze how the priorities of the alternatives shift as the node's priority ranges from 0 to 1.
Each parameter you add will generate a separate sensitivity analysis graph in a new tab.

STEPS

1. Install AhpAnpLib
2. Import Library
3. Create Model **Str.Model**
4. Create Excel file with Model structure (Clusters, nodes and connections)
5. Read structure from excel to python using commands `Input.readStructFromExcel` `Input.readConnectionsFromExcel`
6. Generate an Excel questionnaire to collect judgments **input.export4ExcelQuestFull**
7. Collect judgments in a new Excel file using the generated questionnaire
8. import the filledin Excel questionnaire and use it to calculate results `calc.calcAHPMatricesSave2File`
9. Perform sensitivity analysis `calc.sensitivityCellSupermatrixPlot`

FULL PYTHON CODE

```
!pip install AhpAnpLib

from AhpAnpLib import structs_AHPLib as str
from AhpAnpLib import inputs_AHPLib as input
from AhpAnpLib import calcs_AHPLib as calc
from AhpAnpLib import ratings_AHPLib as rate

#create model
location=str.Model("Site selection")

from google.colab import drive
drive.mount('/content/drive', force_remount=True)
#read structure from Excel
input.readStructFromExcel(location,"/content/drive/My Drive/Colab Notebooks/site selection case.xlsx","structure",False)
#read connections from Excel
input.readConnectionsFromExcel(location,"/content/drive/My Drive/Colab Notebooks/site selection case.xlsx","connection",False)
#print model structure
location.printStruct()

#export excel questionnaire
input.export4ExcelQuestFull(location,"/content/drive/My Drive/Colab Notebooks/AHP_Site_selection_Excel_questionnaire_empty.xlsx",True)
# import my questionnaire and import back to python libarary
calc.calcAHPMatricesSave2File(location,"/content/drive/My Drive/Colab/Notebooks/AHP_Site_selection_Excel_questionnaire_filledin.xlsx","/content/drive/My
Drive/Colab/Notebooks/AHP_Site_selection_Excel_questionnaire_results.xlsx",True,False,True)

#sensitivity analysis
calc.sensitivityCellSupermatrixPlot(location,"Alternatives","/content/drive/My Drive/Colab
Notebooks/AHP_Site_selection_Excel_questionnaire_results.xlsx",False,"Cost","Location","Infrastructure","Employee Satisfaction")
```

Importing structure and judgments from given SuperDecisions file (.sdmod)

New Jupyter notebook

model variable

Name of the model: It will be part of the generated files' name

The file name and path of the *.sdmod file to import in python

```
# Create model
from google.colab import drive
drive.mount('/content/drive', force_remount=True)

SD_siteSelection = input.readSDMODfile("Site selection","/content/drive/My Drive/Colab Notebooks/site selection.sdmod",
True,False)
```

verb: whether to display the calculation details – "False": no details will be displayed

Whether to generate a python file that contains the commands of creating the model using python. True: A Python file will be generated

By default, it is False and will not generate a Python file

Results

Generated Files when executing the Python

A full Python model, that includes all the necessary commands to create a python model equivalent to your original SuperDecisions model

Site selection.py

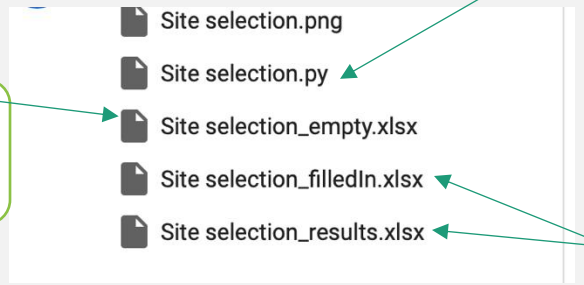
```
from AhpAnpLib import inputs_AHPLib as input
from AhpAnpLib import structs_AHPLib as str
from AhpAnpLib import calcs_AHPLib as calc
from AhpAnpLib import ratings_AHPLib as rate
from AhpAnpLib import functions_AHPLib as reqLib

new_model=str.Model("Site selection")

cl0=str.Cluster("Alternatives",0)
nd0=str.Node("City Center",0)
cl0.addNode2Cluster(nd0)
nd0=str.Node("Industrial Park",1)
cl0.addNode2Cluster(nd0)
nd0=str.Node("Suburban Area",2)
cl0.addNode2Cluster(nd0)
new_model.addCluster2Model(cl0)

cl1=str.Cluster("Criteria",1)
nd1=str.Node("Cost",3)
cl1.addNode2Cluster(nd1)
nd1=str.Node("Employee Satisfaction",4)
cl1.addNode2Cluster(nd1)
nd1=str.Node("Infrastructure",5)
cl1.addNode2Cluster(nd1)
nd1=str.Node("Location",6)
cl1.addNode2Cluster(nd1)
new_model.addCluster2Model(cl1)

cl2=str.Cluster("Decision Makers",2)
nd2=str.Node("CEO",7)
cl2.addNode2Cluster(nd2)
nd2=str.Node("HR Manager",8)
cl2.addNode2Cluster(nd2)
nd2=str.Node("Operations Manager",9)
cl2.addNode2Cluster(nd2)
new_model.addCluster2Model(cl2)
```



Excel file that is a questionnaire with no judgment entries

Filled-in Excel file that is the questionnaire with the judgments from the SuperDecisions file

Excel file containing the original SuperDecisions results

RESOURCES

Download more examples from:
HTTPS://GITHUB.COM/CREATIVEDECISIONS/AHPANPLIB/TREE/MAIN/EXAMPLES

Check more videos on CDF YouTube channel:
HTTPS://YOUTUBE.COM/PLAYLIST?LIST=PL_J2C3IKVYPVPVP6PUTNLVPKD-MIXHEER&SI=DQLG0BBJPPXHOTSH

Check CDF resources:
HTTPS://WWW.CREATIVEDECISIONS.NET/RESOURCES/

Q&A / TROUBLESHOOTING

weileerong@foxmail.com