0. PROGRAMMING WITH R
1. ANALYTIC QUESTIONS
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3. VECTORS
4. DATA FRAMES
5. LOAD DATA
6. TIDY DATA
7. STRINGS
8. TRANSFORM DATA
9. UNSTRUCTURED DATA
10. VISUALIZE DATA
11. COMMUNICATE FINDINGS
12. PYTHON
13. MACHINE LEARNING

# PROGRAMMING WITH R

# variables

# control structures

# loops

# functions

# libraries

# ANALYTIC QUESTIONS

BACK

did you summarize the
data?



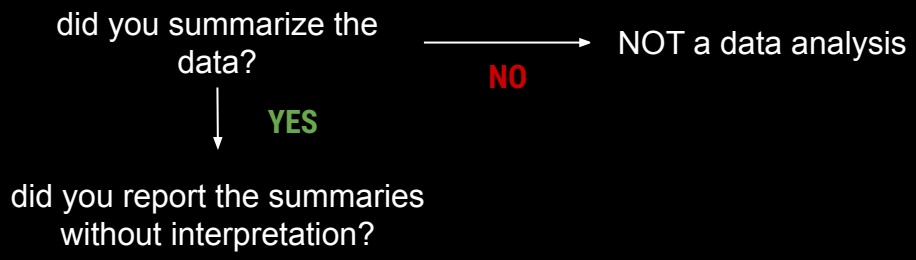
Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.

did you summarize the data? → NOT a data analysis

NO

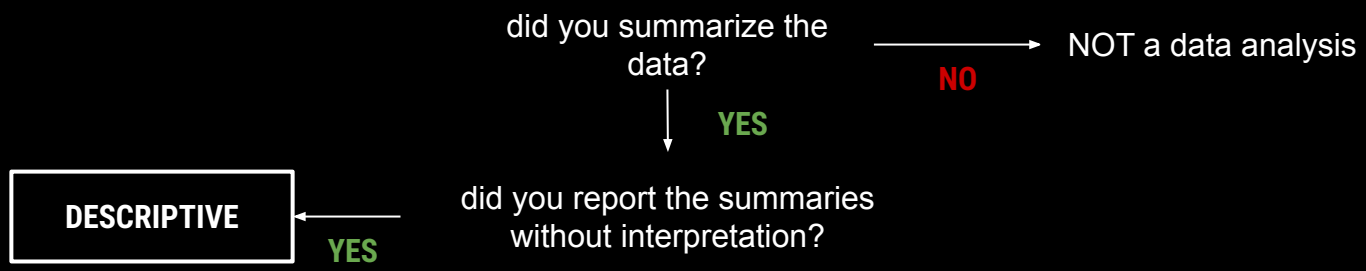


Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.






Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.



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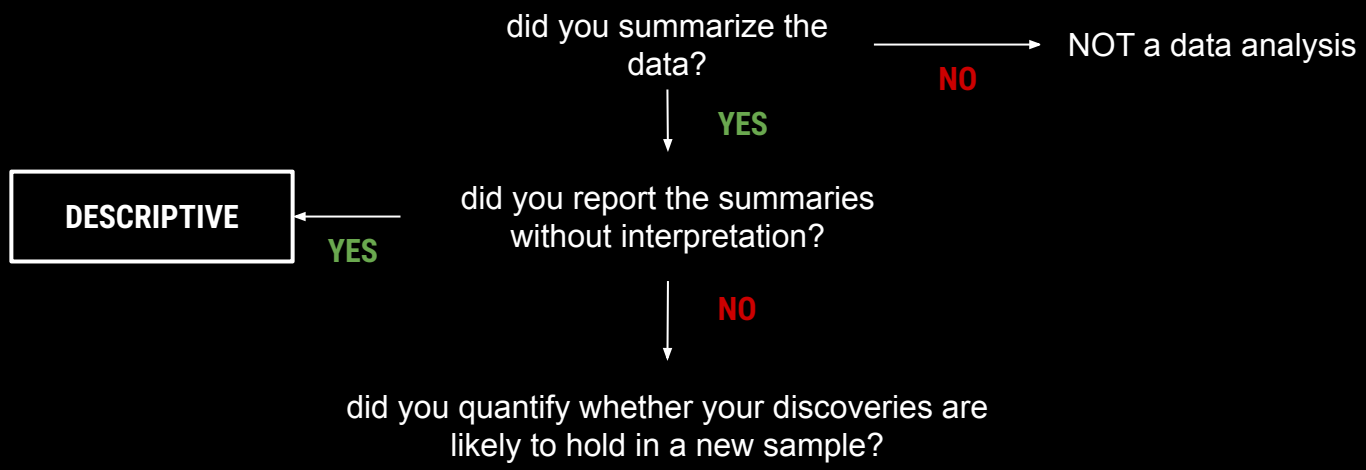
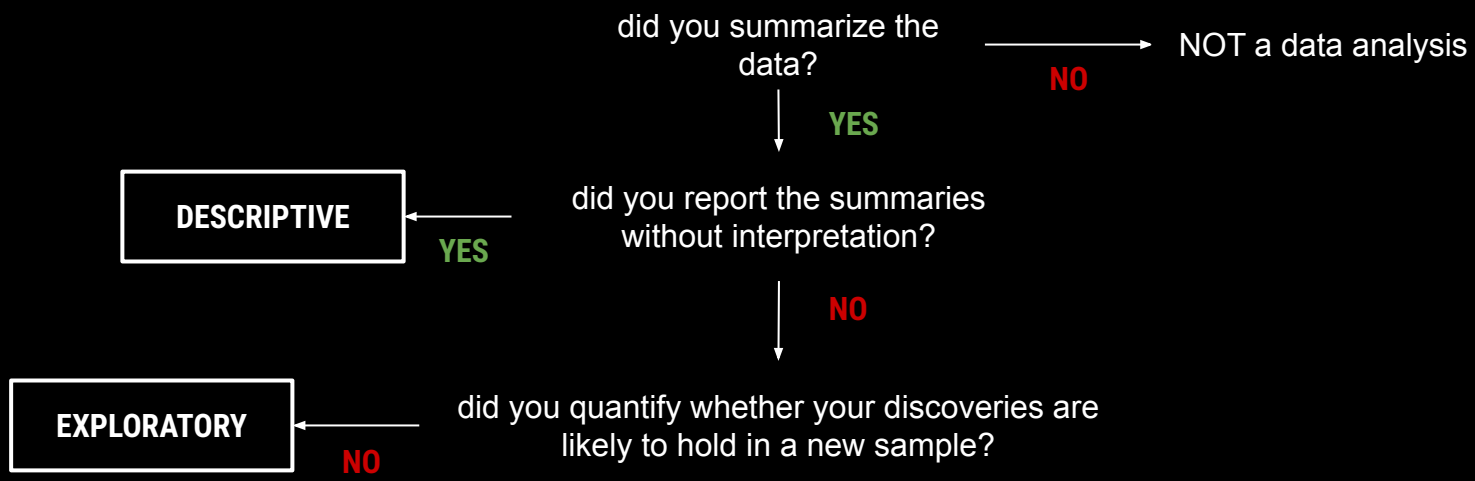
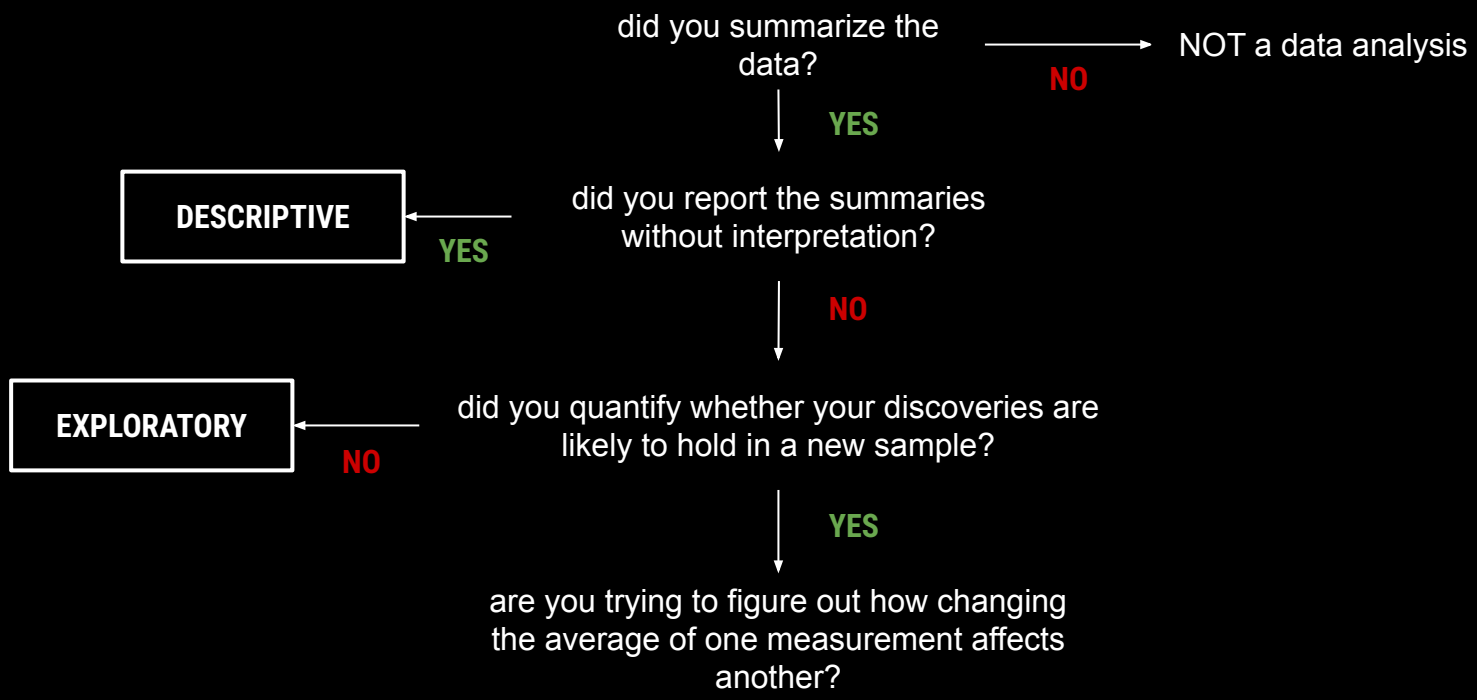


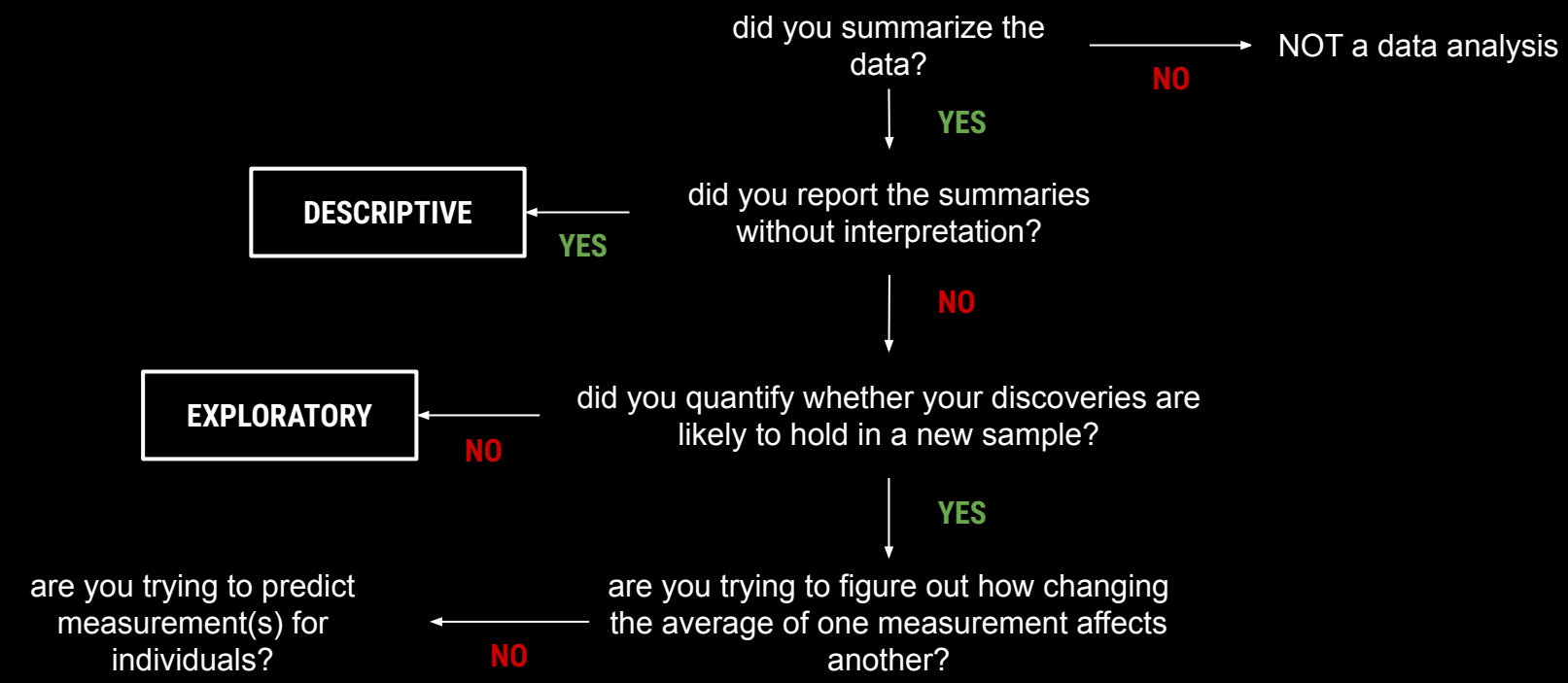

Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.




Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.




Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.

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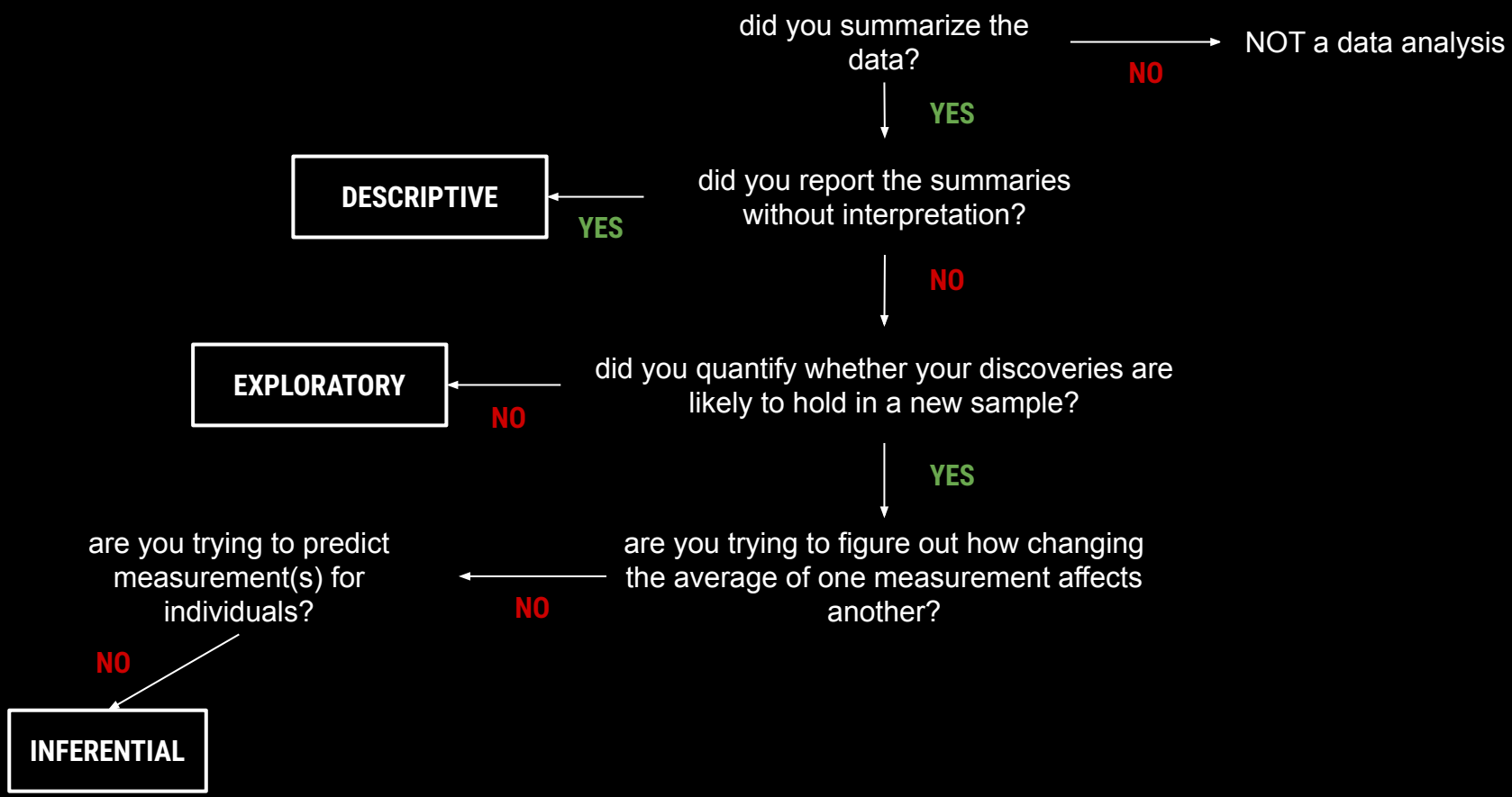


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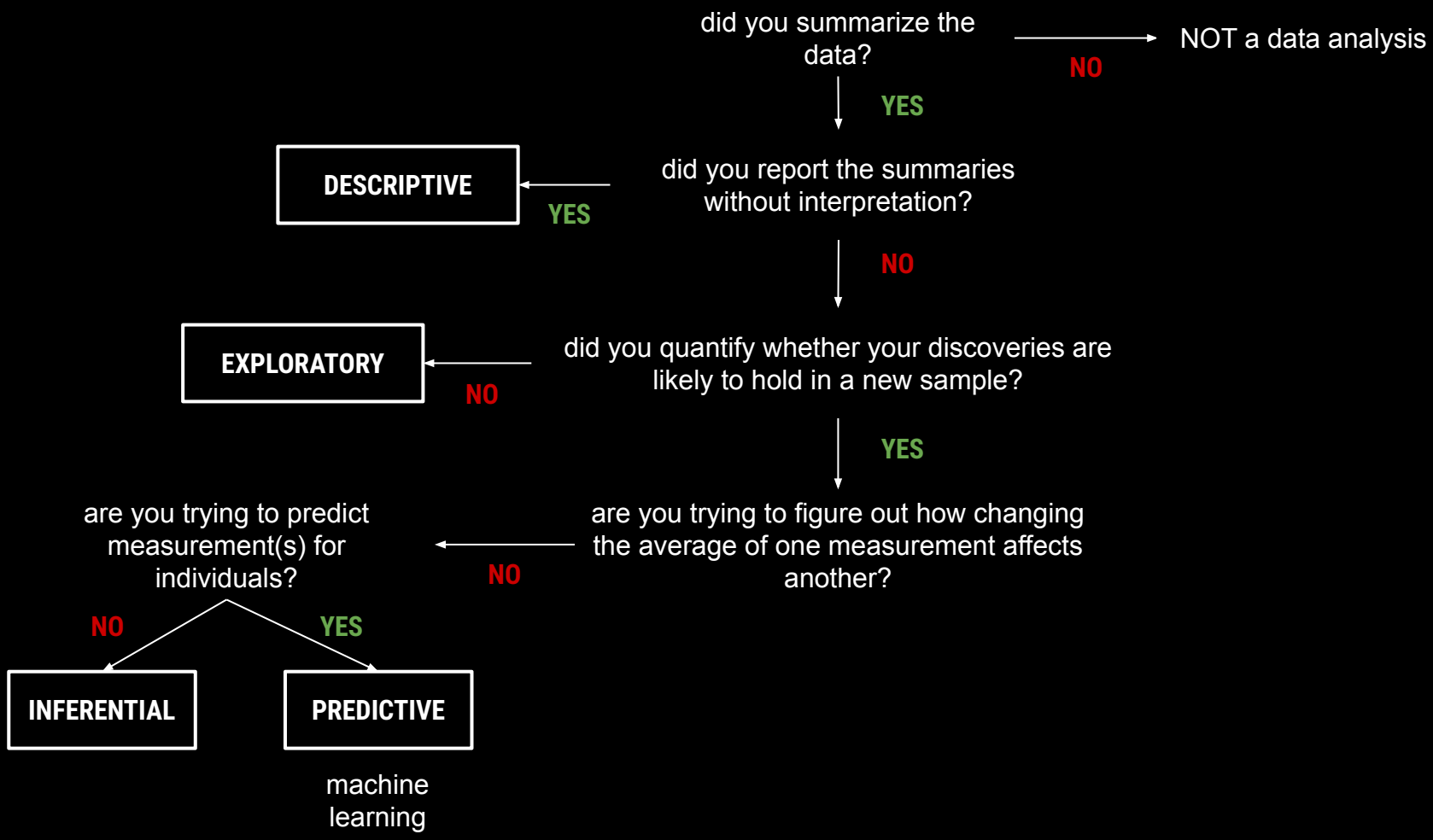


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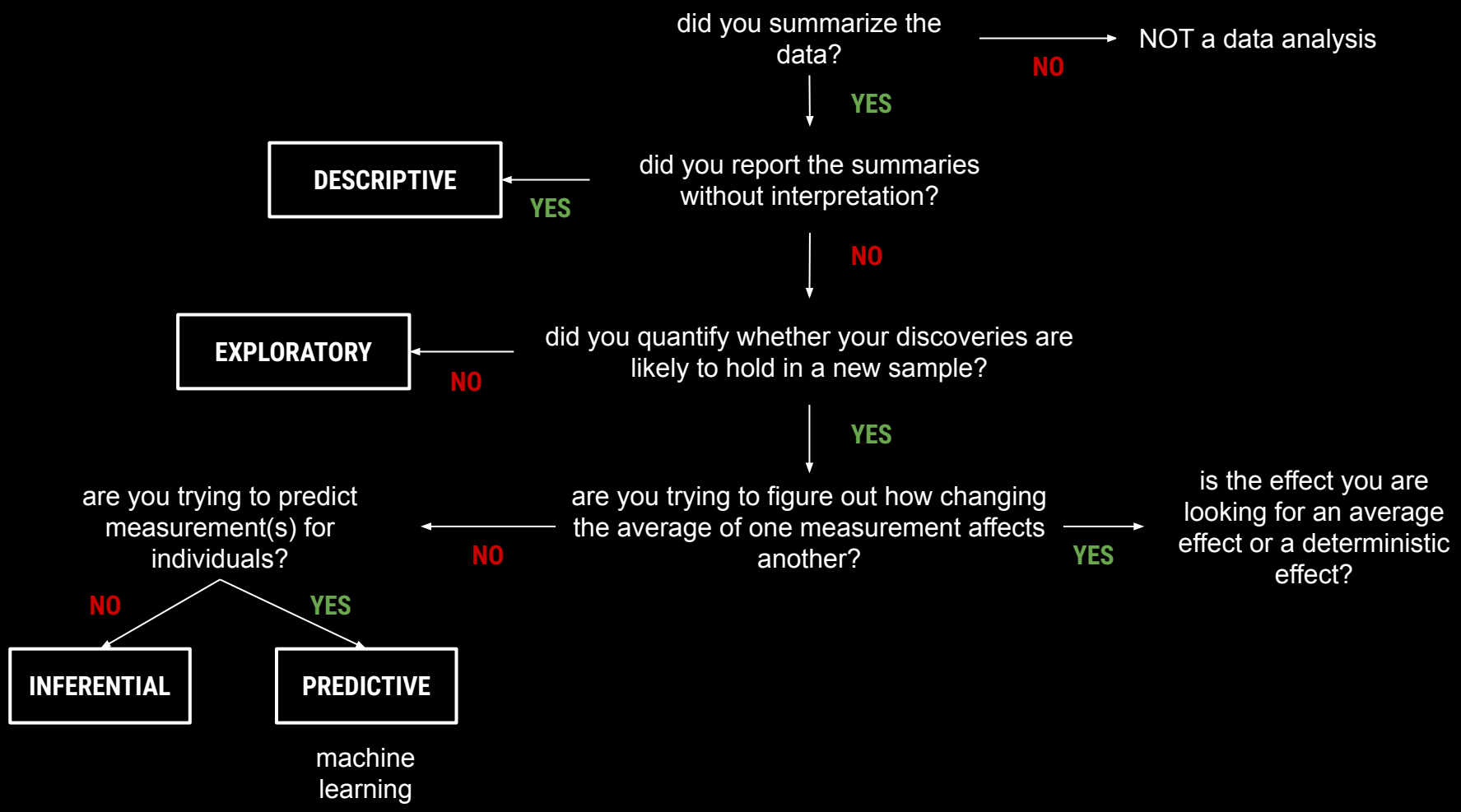


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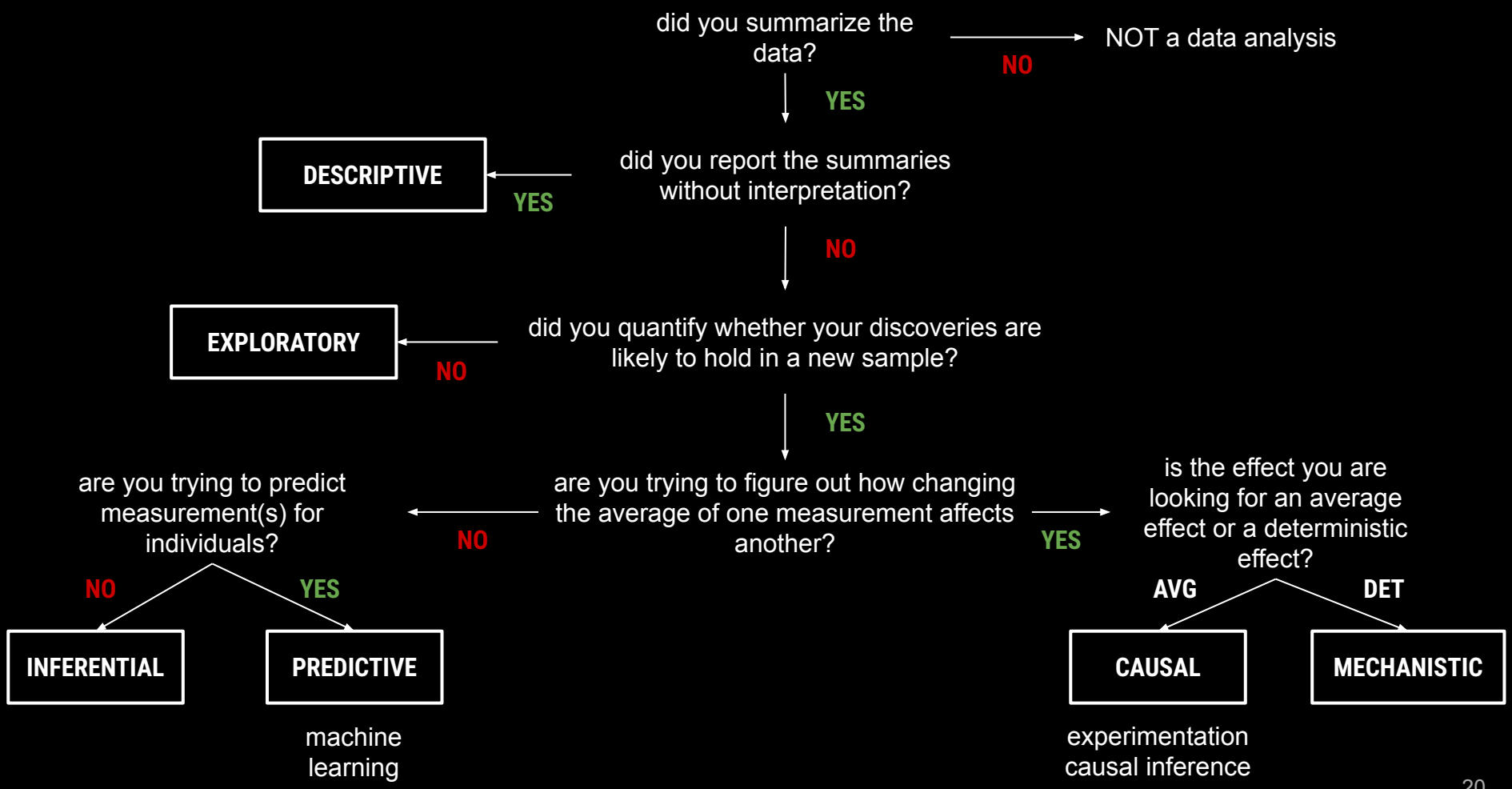


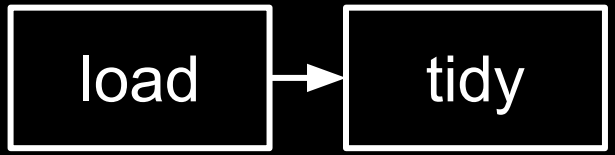

Quelle: Jeffery T. Leek, Roger D. Peng: What is the question? Science 20.03.2015: 1314-1315.

# EXPLORATORY DATA ANALYSIS

BACK

load

Following Wickham, Hadley, et al. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. 2nd edition, O'Reilly Media, Inc, 2023.

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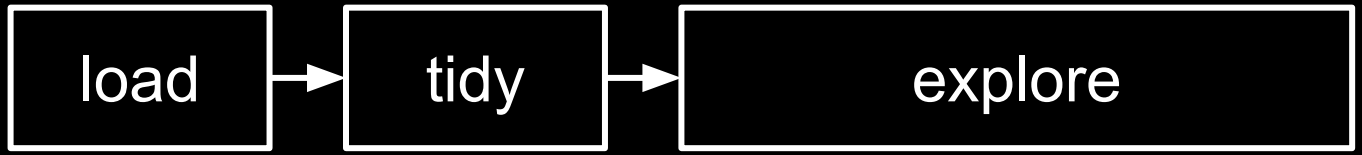


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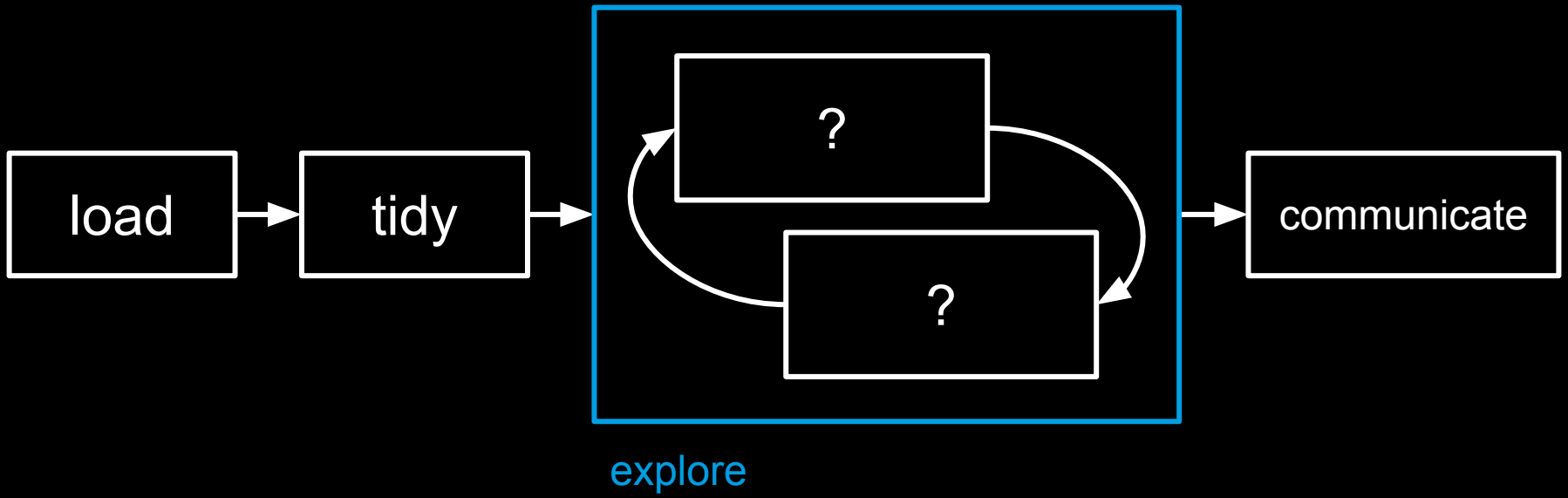


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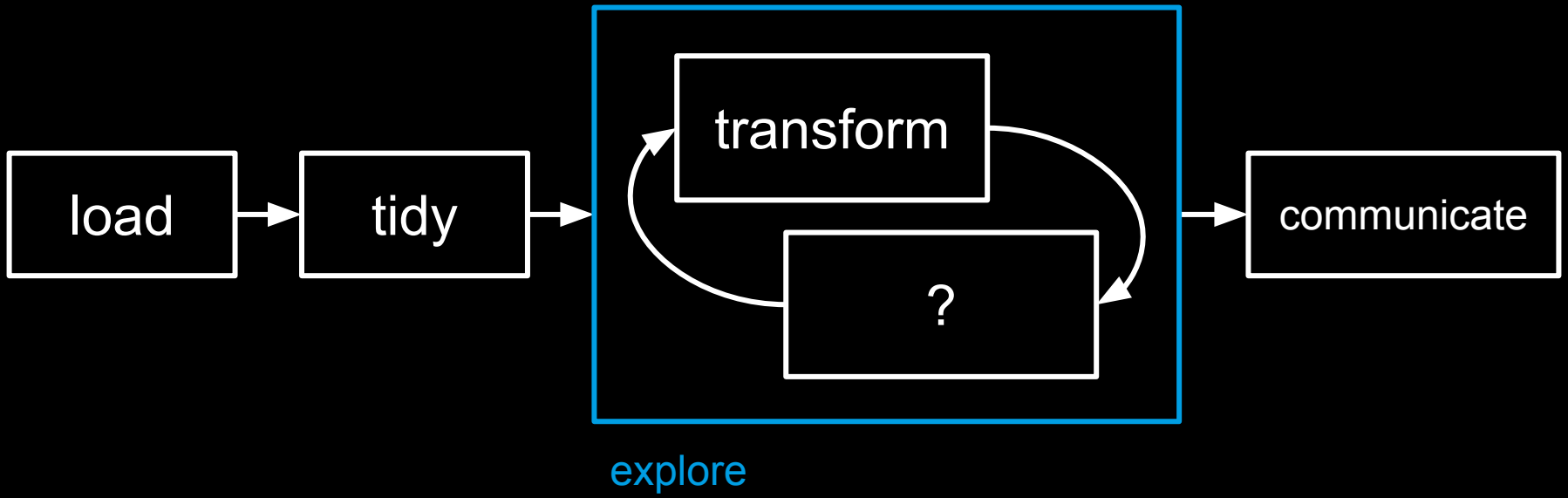


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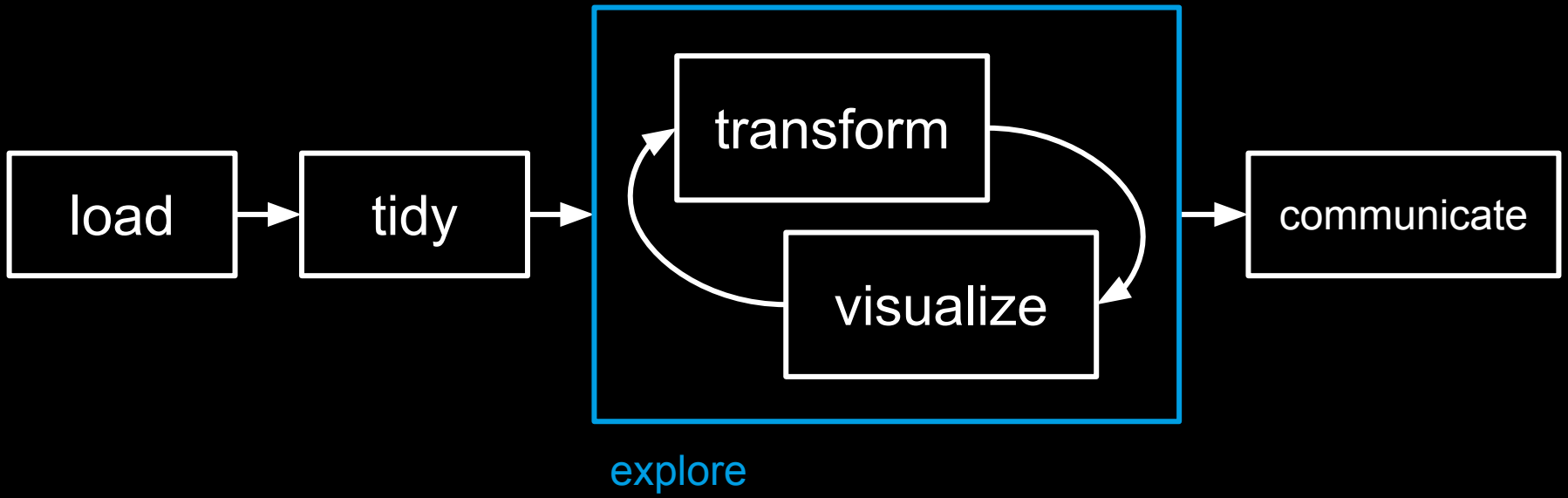


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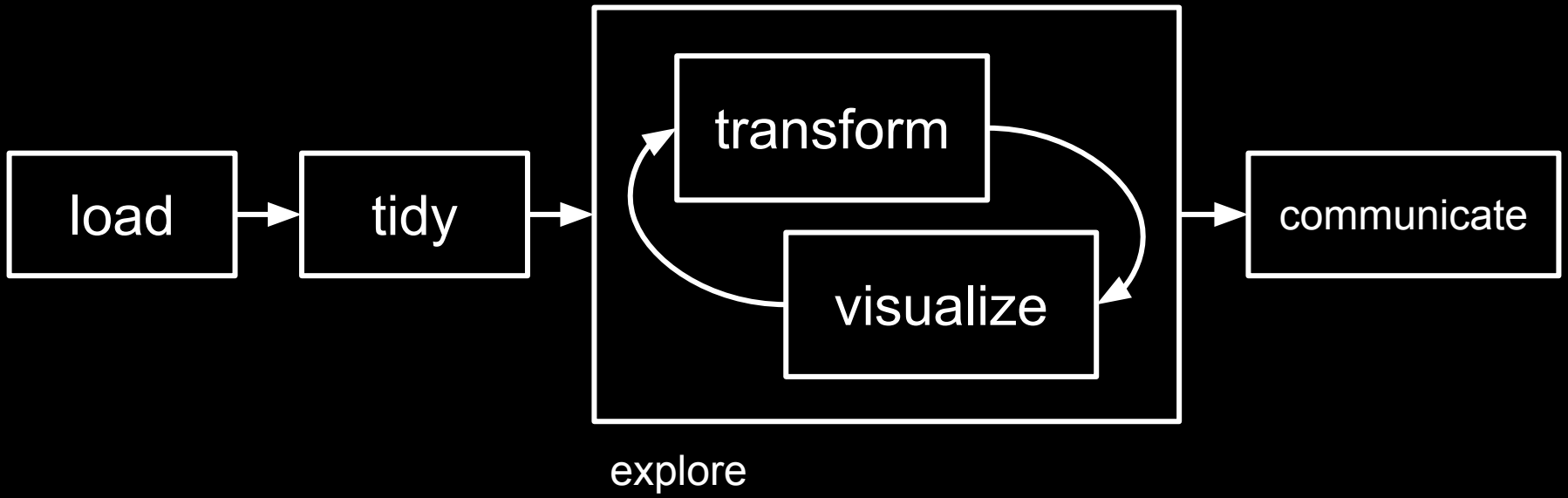


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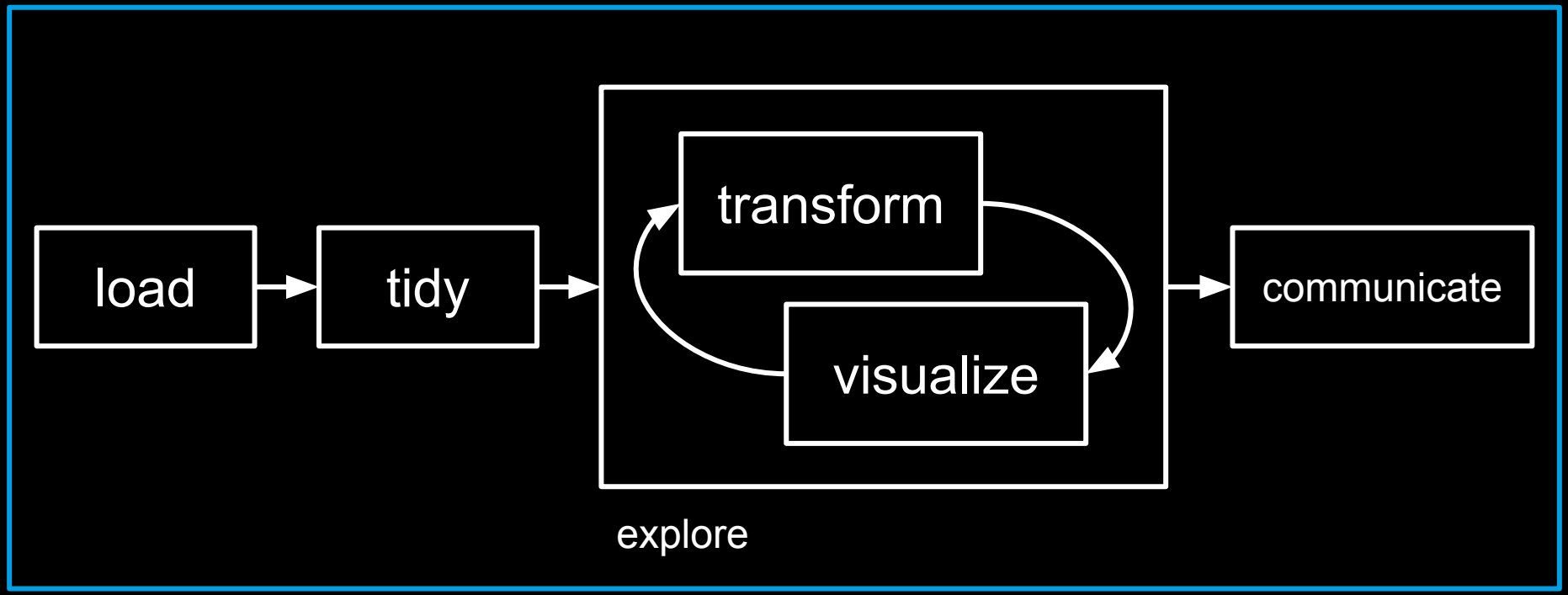


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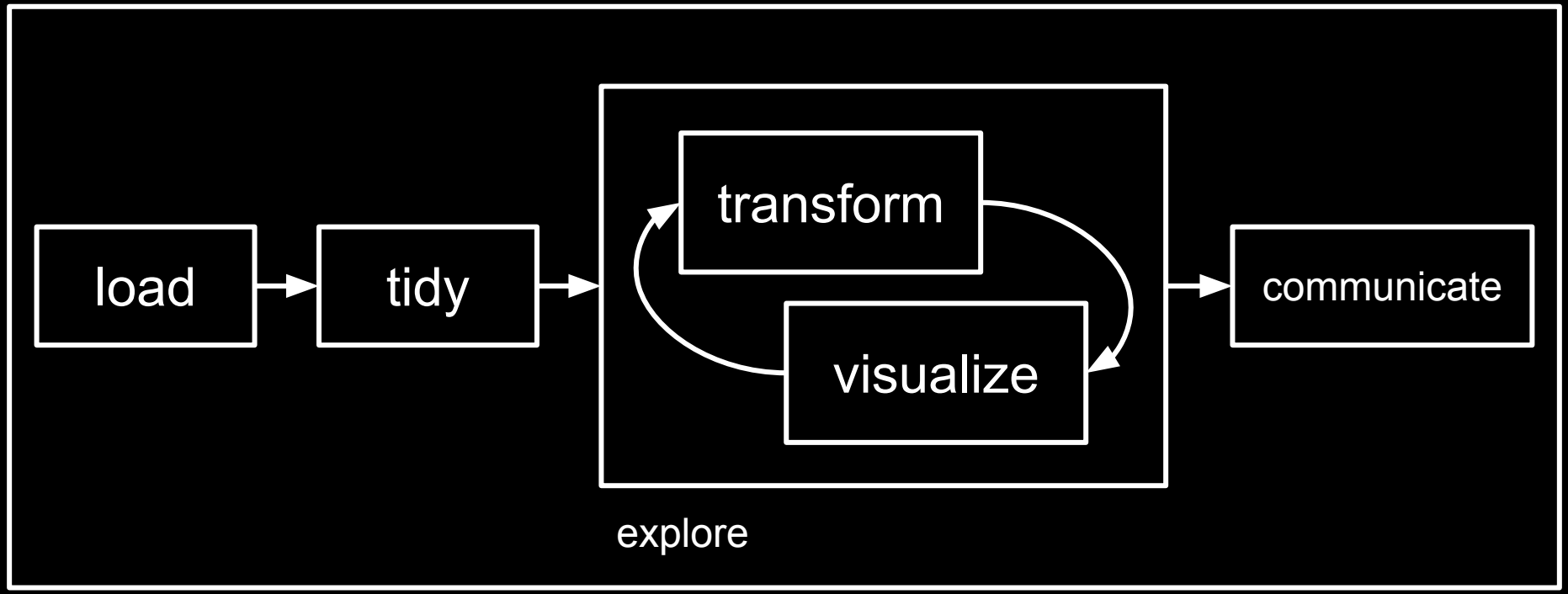



Following Wickham, Hadley, et al. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. 2nd edition, O'Reilly Media, Inc, 2023.

# VECTORS

```
c(2, 3, 5, 7, 11, 13, 17)
```

# DATA FRAMES

{{ tibble }}

# LOAD DATA

{{ readr }}

```
read_csv()
read_delim()
```

{{ readxl }}

# read_excel()

# TIDY DATA

BACK

# tidy data

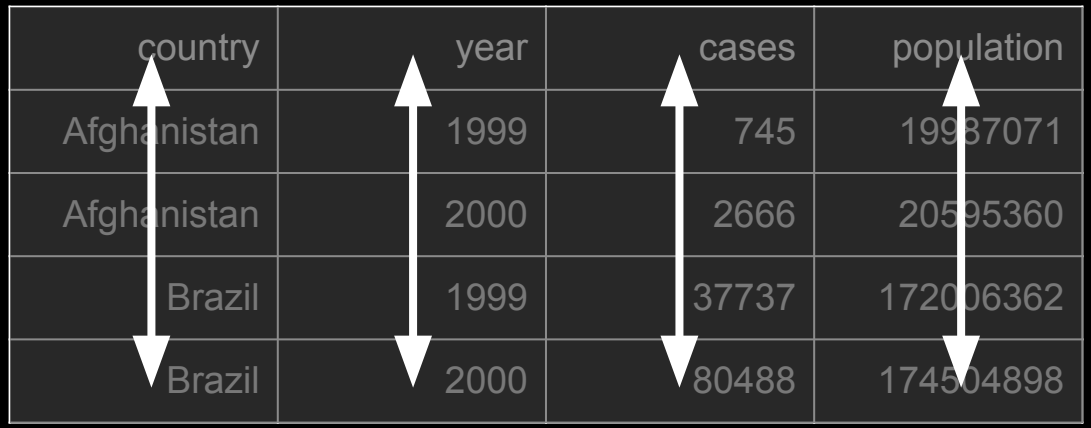
each variable is a column;
each column is a variable.

each observation is a row;
each row is an observation.

each value is a cell;
each cell is a single value.

| country | year | cases | population |
|---|---|---|---|
| Afghanistan | 1999 | 745 | 19987071 |
| Afghanistan | 2000 | 2666 | 20595360 |
| Brazil | 1999 | 37737 | 172006362 |
| Brazil | 2000 | 80488 | 174504898 |

Example from: Wickham, Hadley, et al. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. 2nd edition, O'Reilly Media, Inc, 2023. Chapter 5.


country
year
cases
population
Afghanistan
1999
745
19987071
Afghanistan
2000
2666
20595360
Brazil
1999
37737
172006362
Brazil
2000
80488
174504898

# variables

| country | year | cases | population |
| --- | --- | --- | --- |
| Afghanistan | 1999 | 745 | 19987071 |
| Afghanistan | 2000 | 2666 | 20595360 |
| Brazil | 1999 | 37737 | 172006362 |
| Brazil | 2000 | 80488 | 174504898 |

observations

| country | year | cases | population |
| --- | --- | --- | --- |
| Afghanistan | 1999 | 745 | 19987071 |
| Afghanistan | 2000 | 2666 | 20595360 |
| Brazil | 1999 | 37737 | 172006362 |
| Brazil | 2000 | 80488 | 174504898 |

values

| country | year | type | count |
|---|---|---|---|
| Afghanistan | 1999 | cases | 745 |
| Afghanistan | 1999 | population | 19987071 |
| Afghanistan | 2000 | cases | 2666 |
| Afghanistan | 2000 | population | 20595360 |
| Brazil | 1999 | cases | 37737 |
| Brazil | 1999 | population | 172006362 |
| Brazil | 2000 | cases | 80488 |
| Brazil | 2000 | population | 174504898 |

| country | year | type | count |
|---|---|---|---|
| Afghanistan | 1999 | cases | 745 |
| Afghanistan | 1999 | population | 19987071 |
| Afghanistan | 2000 | cases | 2666 |
| Afghanistan | 2000 | population | 20595360 |
| Brazil | 1999 | cases | 37737 |
| Brazil | 1999 | population | 172006362 |
| Brazil | 2000 | cases | 80488 |
| Brazil | 2000 | population | 174504898 |

# wider

| country | cases_1999 | cases_2000 | pop_1999 | pop_2000 |
|---|---|---|---|---|
| Afghanistan | 745 | 2666 | 19987071 | 20595360 |
| Brazil | 37737 | 172006362 | 80488 | 174504898 |

# compressed

| country | year | rate |
|---|---|---|
| Afghanistan | 1999 | 745 / 19987071 |
| Afghanistan | 2000 | 2666 / 20595360 |
| Brazil | 1999 | 37737 / 172006362 |
| Brazil | 2000 | 80488 / 174504898 |

# tidy

| country | year | cases | population |
|---|---|---|---|
| Afghanistan | 1999 | 745 | 19987071 |
| Afghanistan | 2000 | 2666 | 20595360 |
| Brazil | 1999 | 37737 | 172006362 |
| Brazil | 2000 | 80488 | 174504898 |

# tidy

| country | year | cases | population |
|---|---|---|---|
| Afghanistan | 1999 | 745 | 19987071 |
| Afghanistan | 2000 | 2666 | 20595360 |
| Brazil | 1999 | 37737 | 172006362 |
| Brazil | 2000 | 80488 | 174504898 |

vector

{{ tidyr }}

# pivot_wider()

# pivot_longer()

# STRINGS

{{ stringr }}

```
str_trim()
str_squish()
```

```
str_starts()
str_ends()
str_detect()
```

“Annabel Miller”

“Annabel Miller”

```
str_starts(txt, "Anna")
```

“Annabel Miller”

```
str_ends(txt, "Miller")
```

“Annabel Miller”

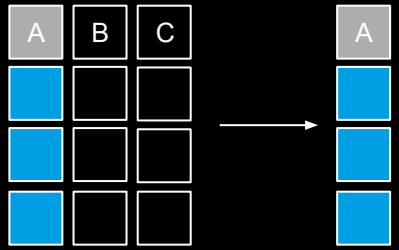
```
str_detect(txt, "Mill")
```

# TRANSFORM DATA

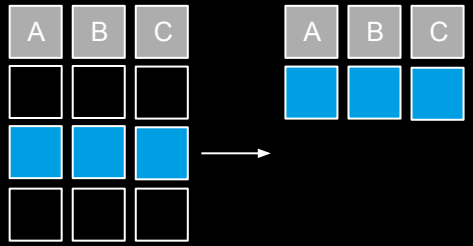
{{ dplyr }}

# types of transformations

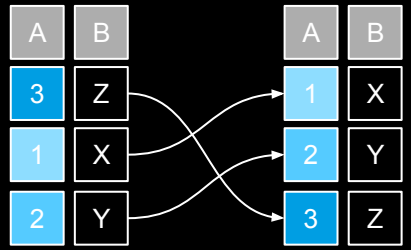
## select()



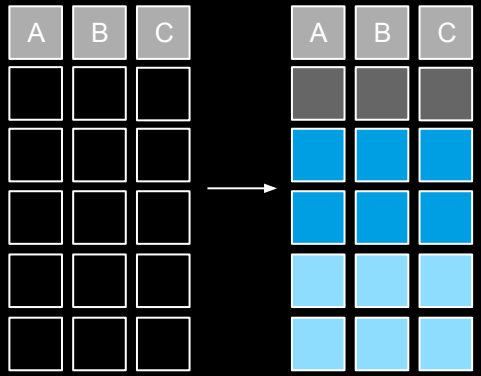

## filter()



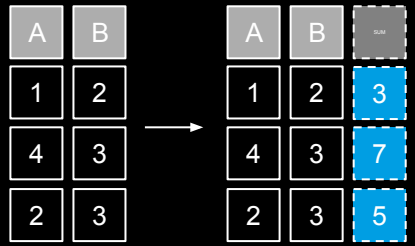

## arrange()



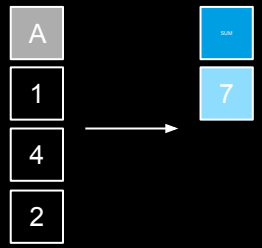

## group_by()



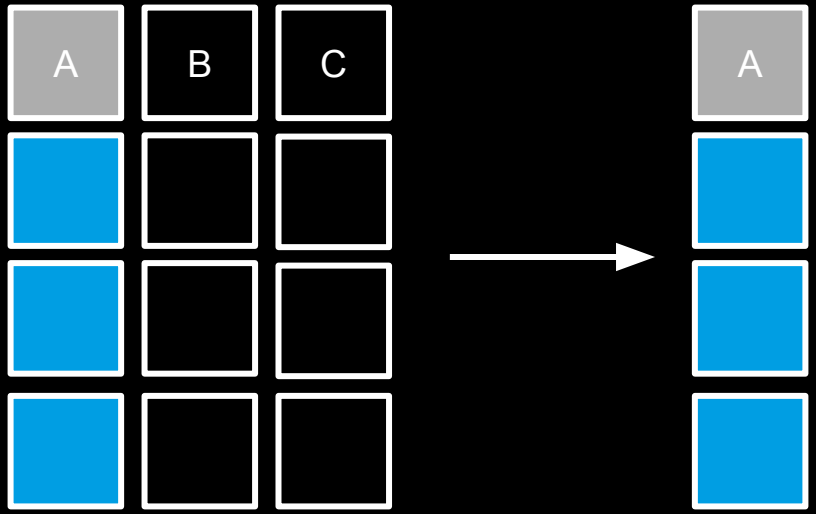

## mutate()



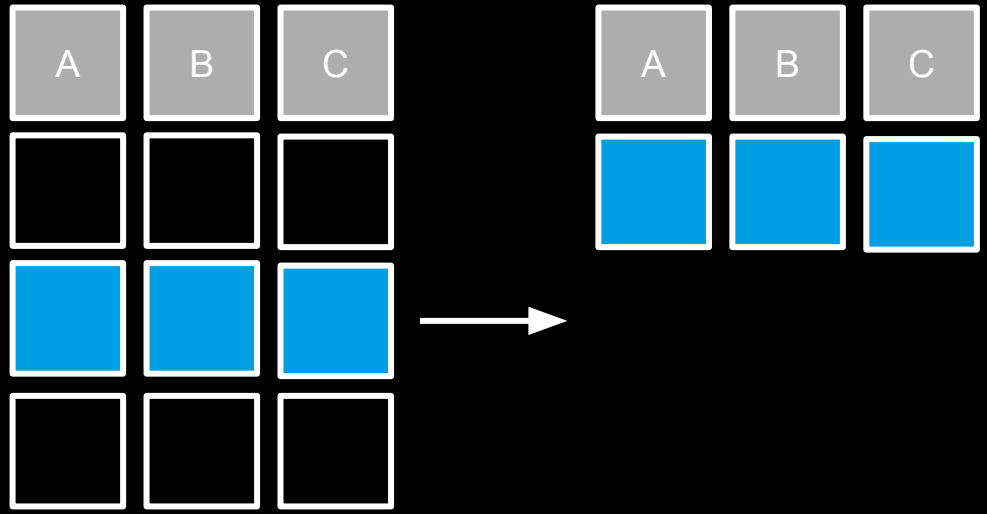

## summarize()



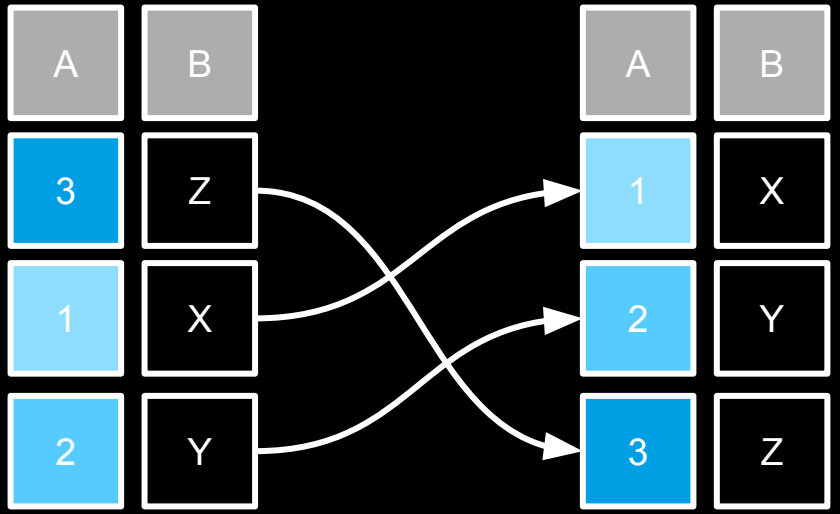
select()



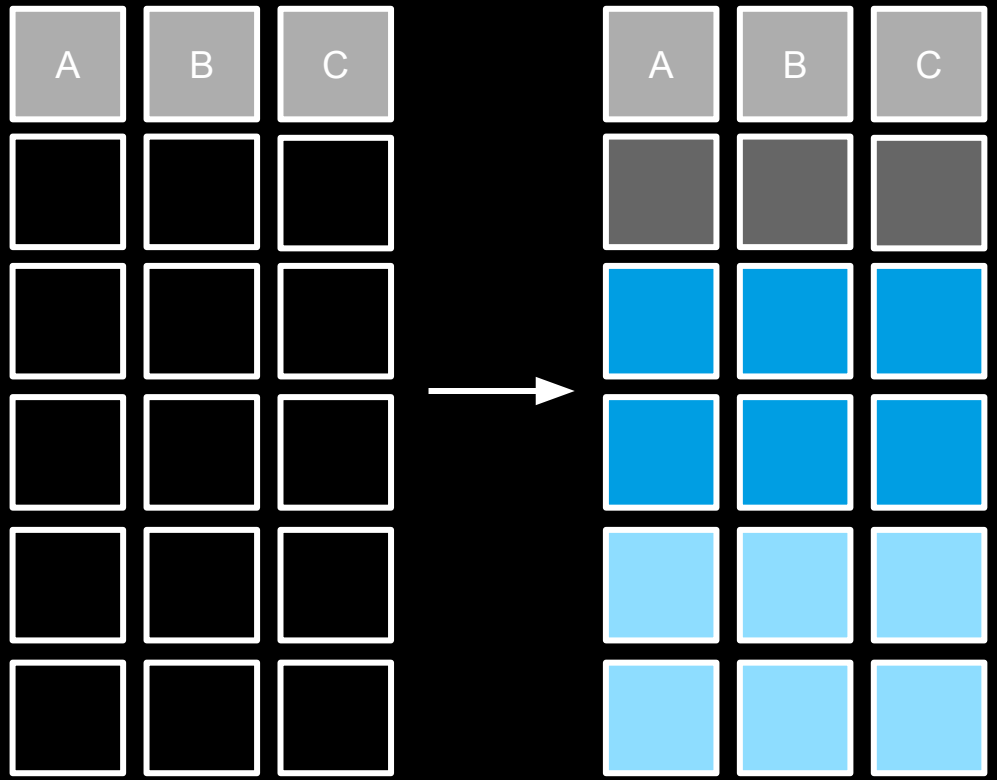
# filter()



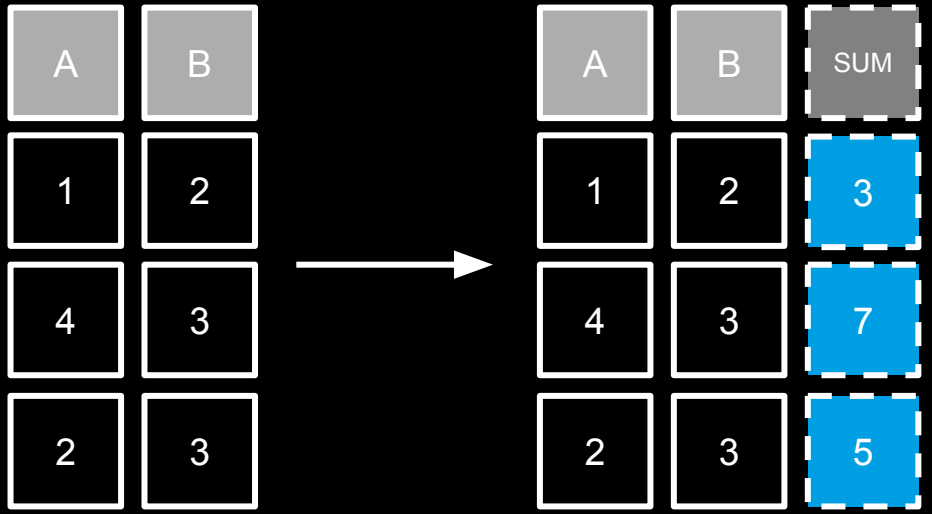
# arrange()



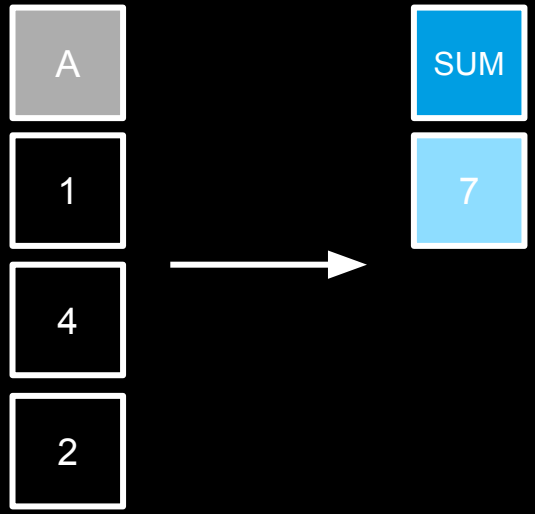
group_by()



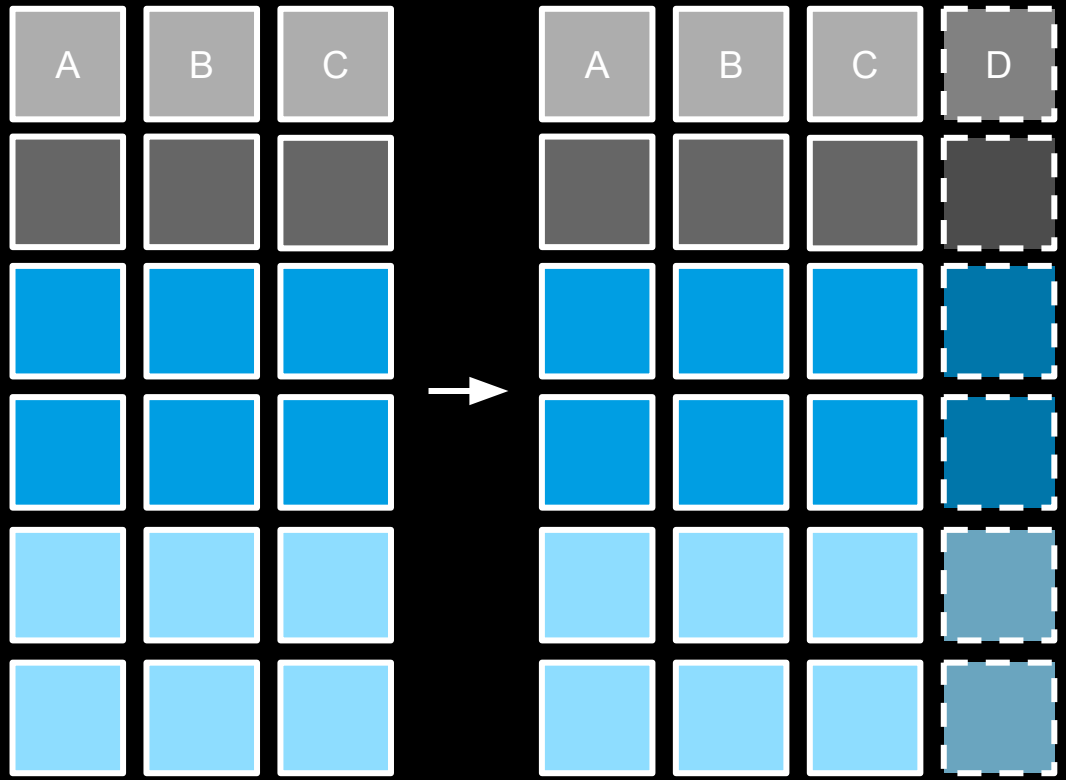
# mutate()



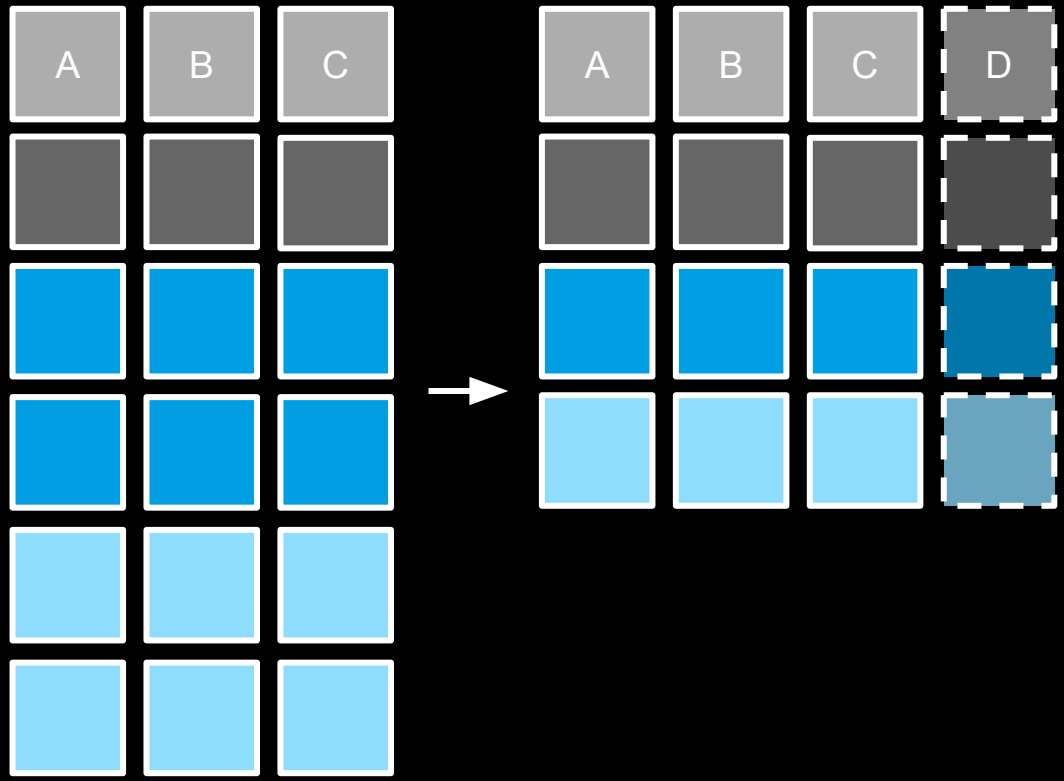
summarize()



```
group_by()
+
mutate()
```

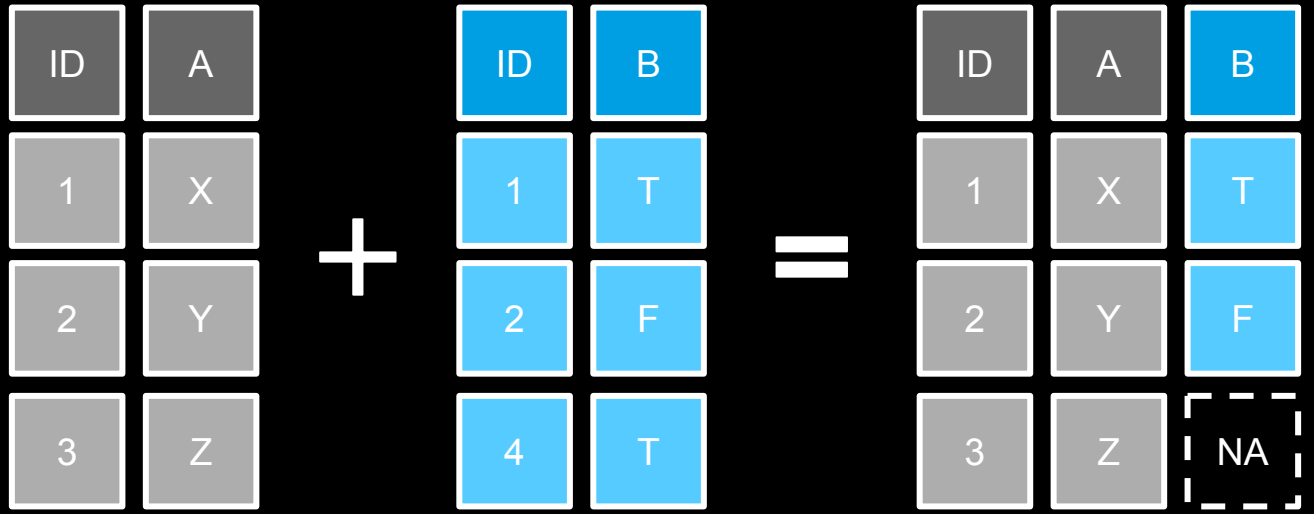


```
group_by()
+
summarize()
```

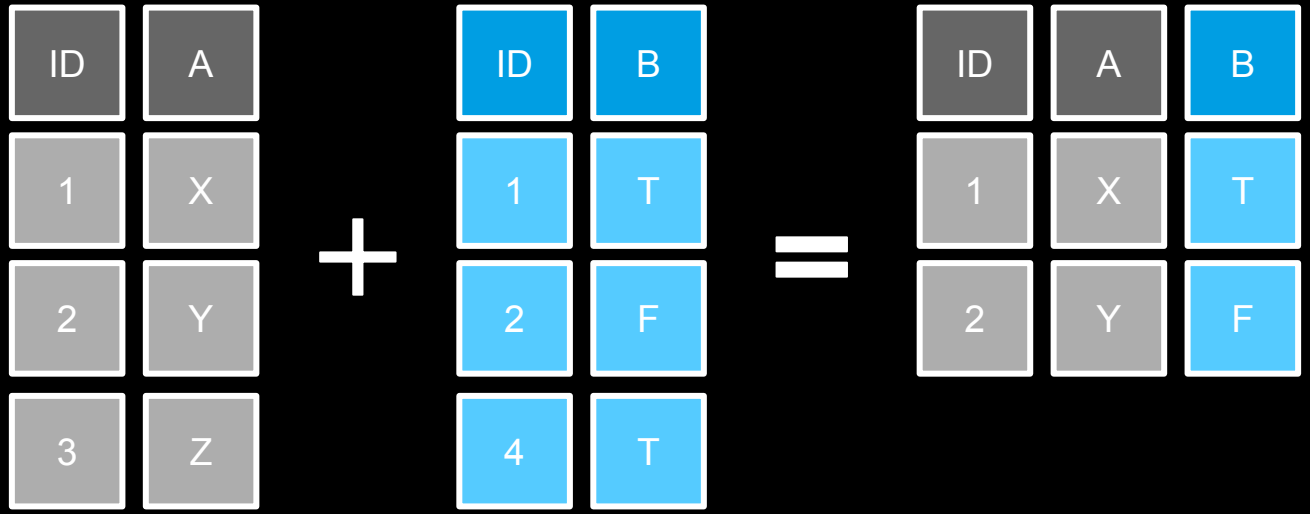


# joining data

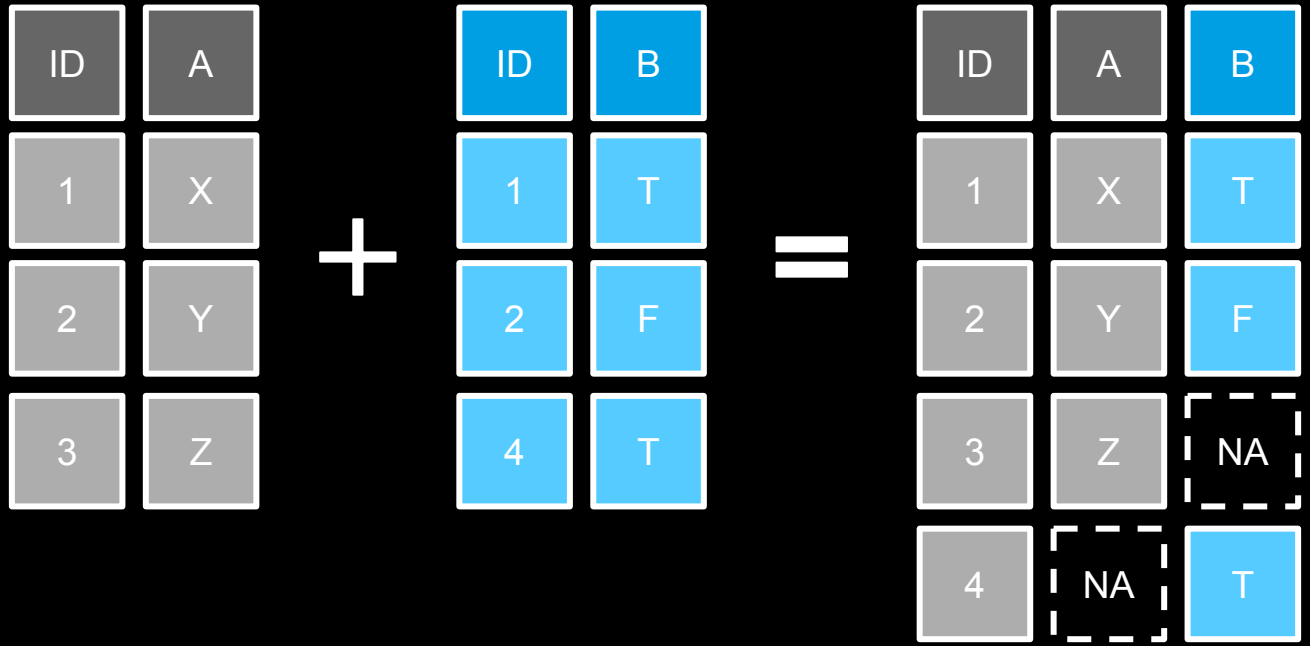
left_join()


ID
A
1
X
2
Y
3
Z
+
ID
B
1
T
2
F
4
T
=
ID
A
B
1
X
T
2
Y
F
3
Z
NA

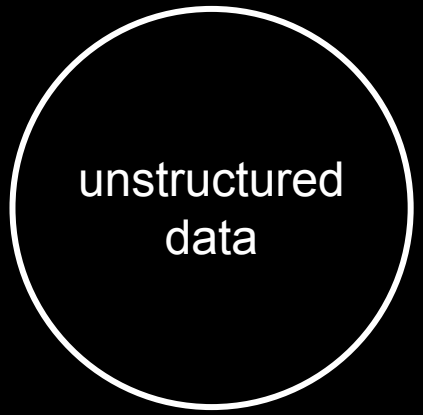
inner_join()


ID
A
1
X
2
Y
3
Z
+
ID
B
1
T
2
F
4
T
=
ID
A
B
1
X
T
2
Y
F

full_join()


ID
A
1
X
2
Y
3
Z
+
ID
B
1
T
2
F
4
T
=
ID
A
B
1
X
T
2
Y
F
3
Z
NA
4
NA
T

# UNSTRUCTURED DATA


unstructured
data

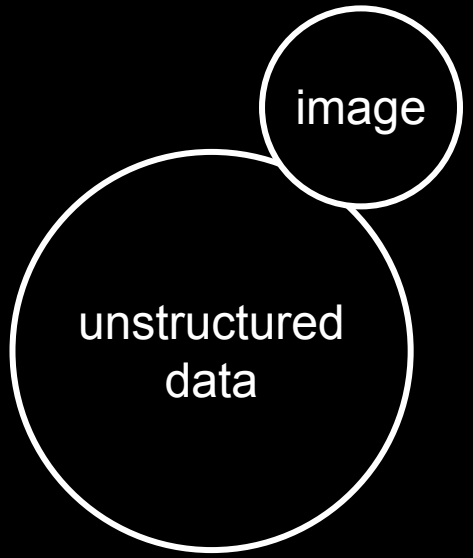


image
unstructured
data

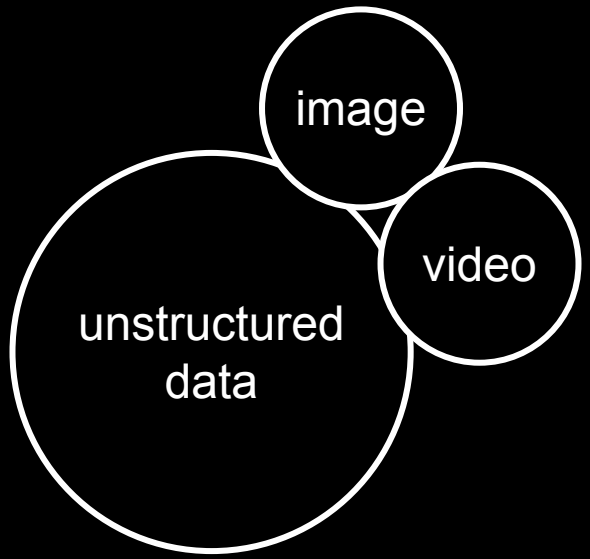


image
video
unstructured
data

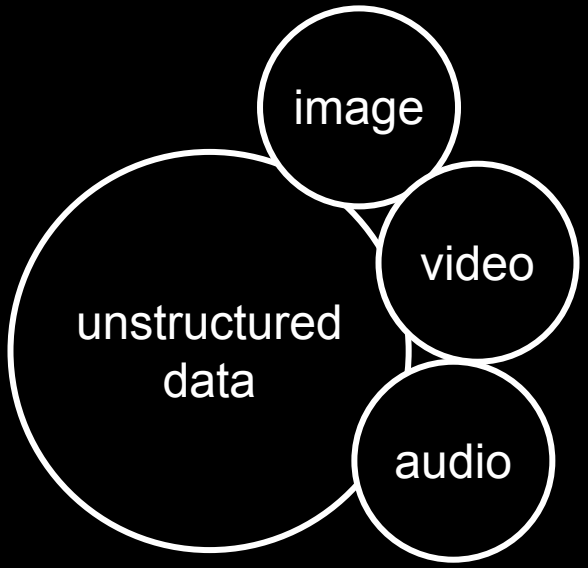


image
video
unstructured
data
audio

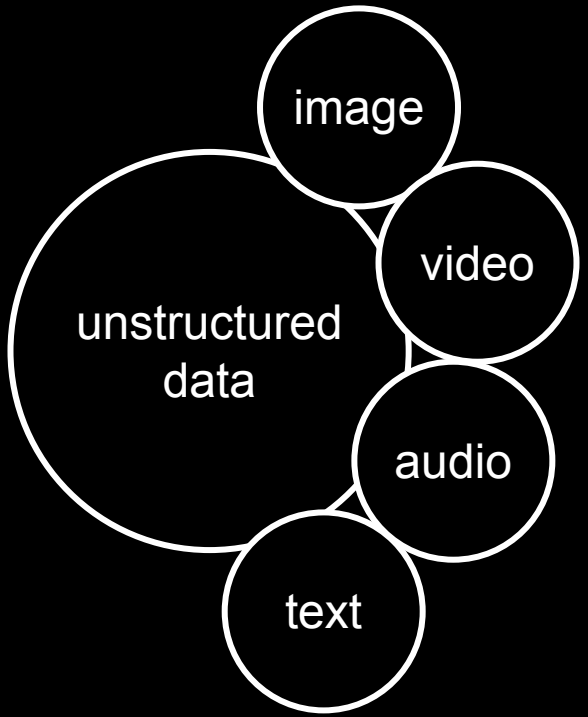
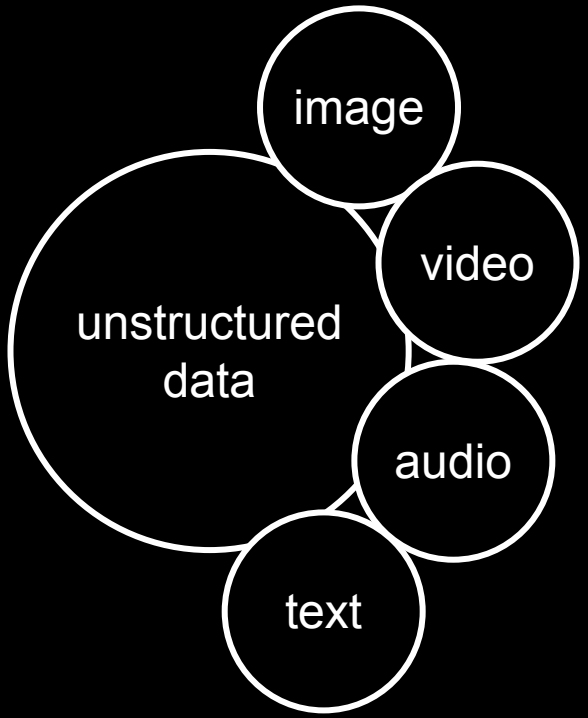
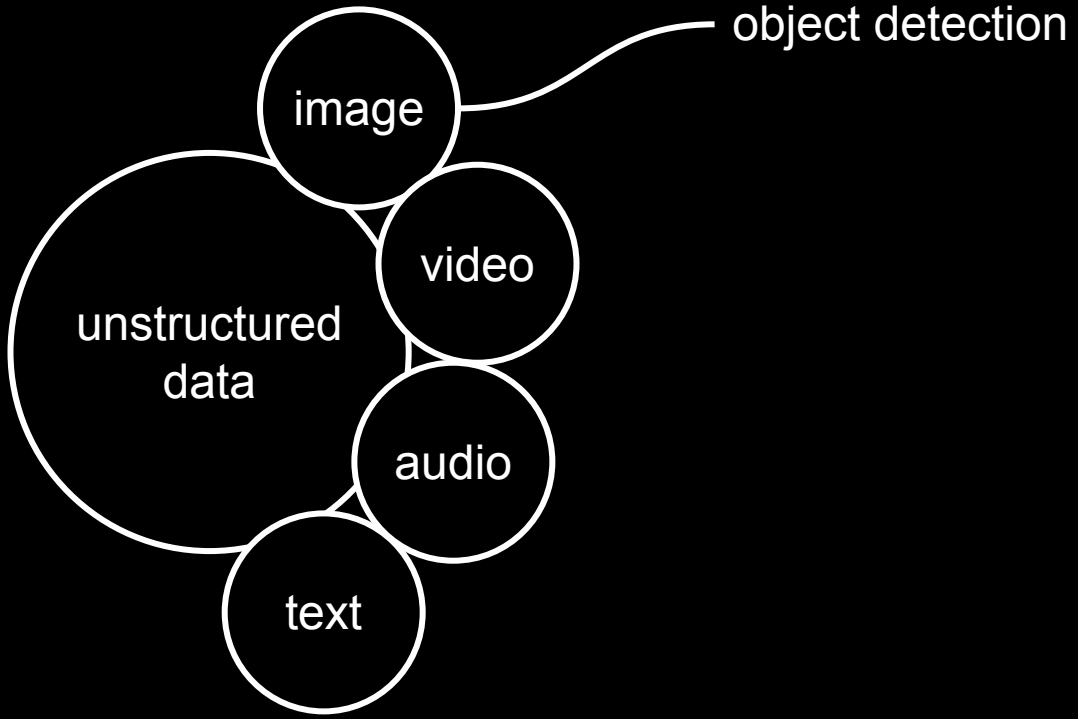


image
video
unstructured
data
audio
text

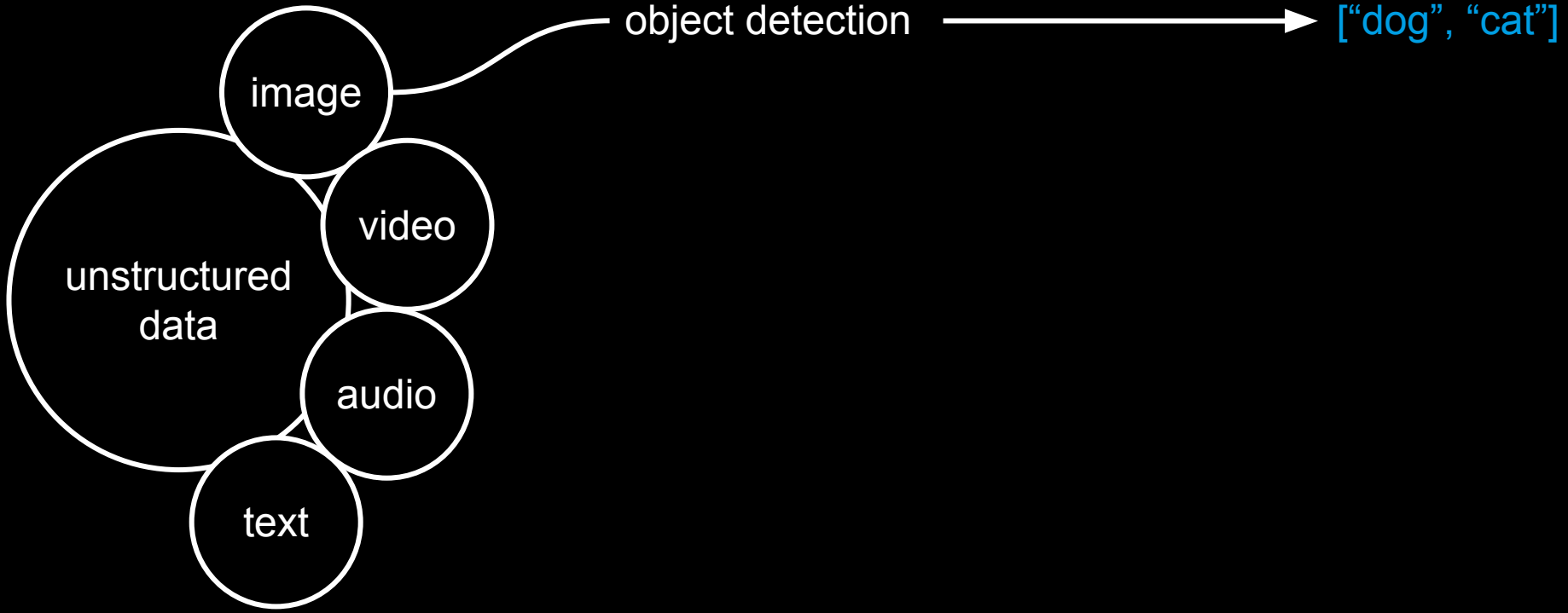
# no handles to grab



# no handles to grab



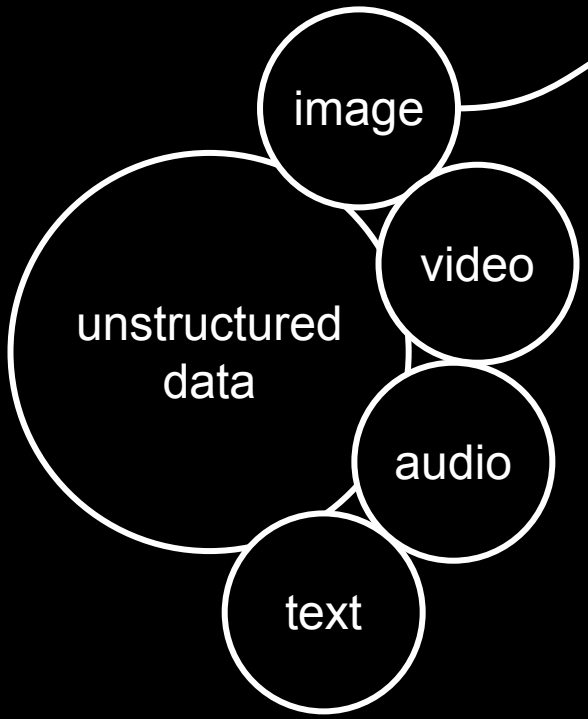
no handles to grab



no handles to grab

algorithm

extracted, structured information

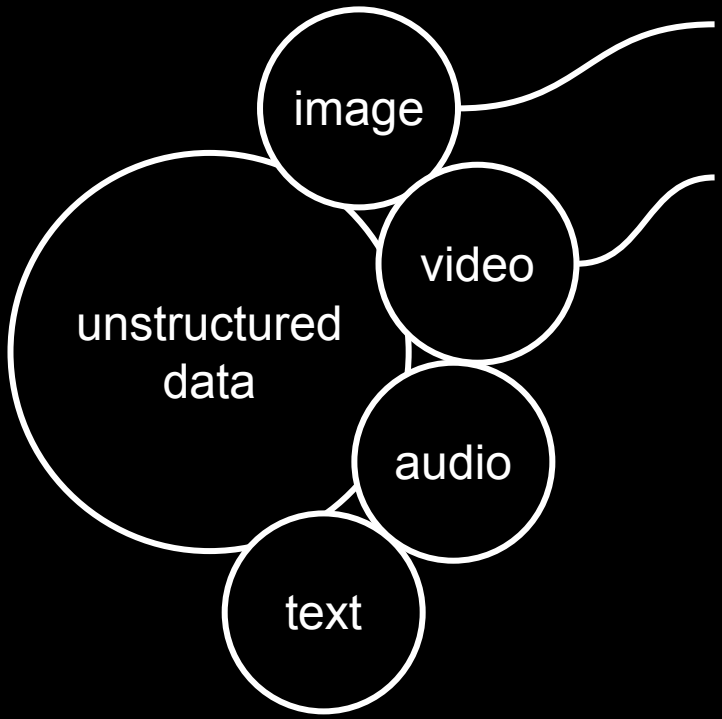



object detection → [“dog”, “cat”]

no handles to grab

algorithm

extracted, structured information



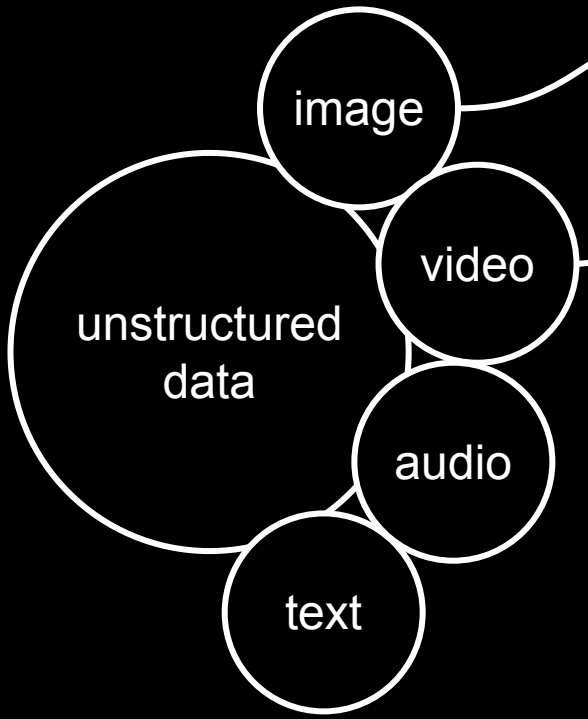

object detection → ["dog", "cat"]

object tracking

no handles to grab

algorithm

extracted, structured information



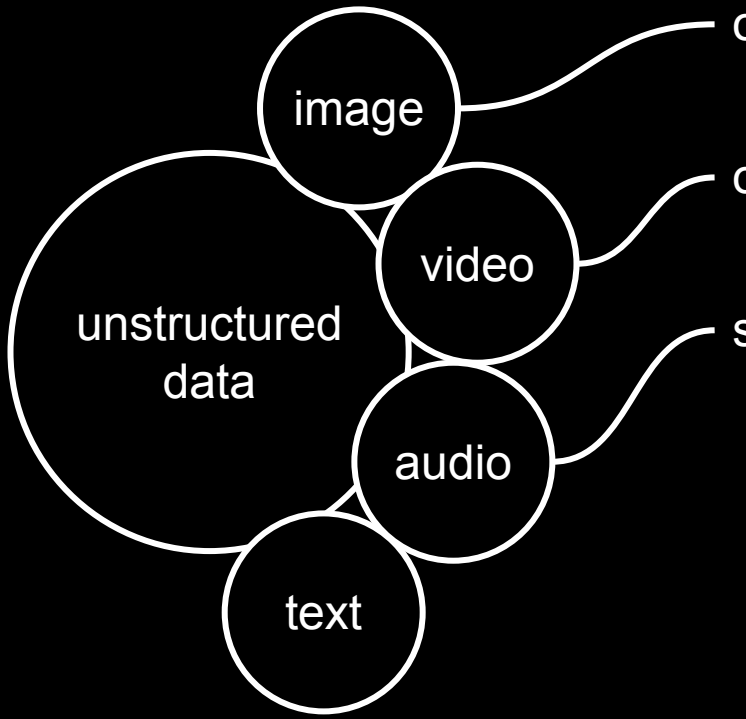

object detection → [“dog”, “cat”]

object tracking → { "t": 2.41, "x": 34, "y": 55 }

no handles to grab

algorithm

extracted, structured information




object detection → ["dog", "cat"]

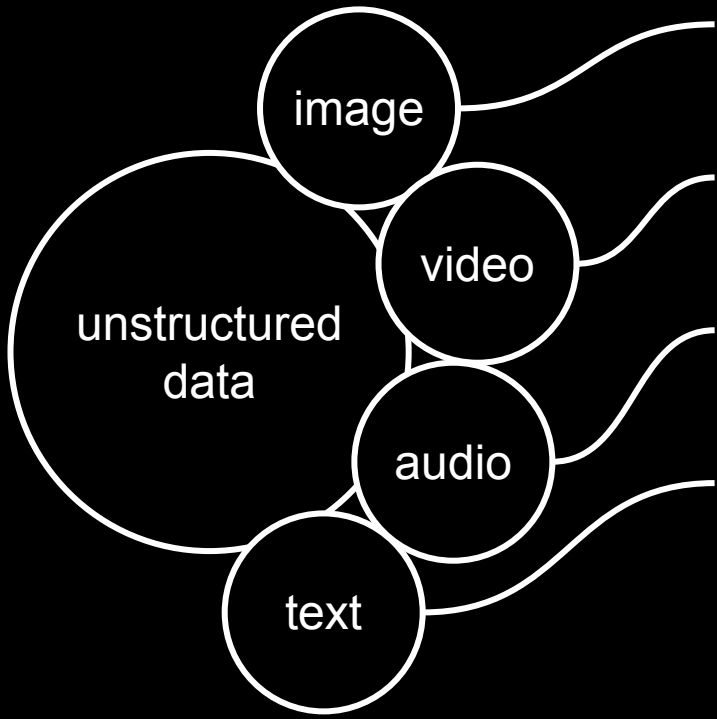
object tracking → { "t": 2.41, "x": 34, "y": 55 }

speech-to-text → { "t": 0.3, "text": "Guten Abend" }

no handles to grab

algorithm

extracted, structured information

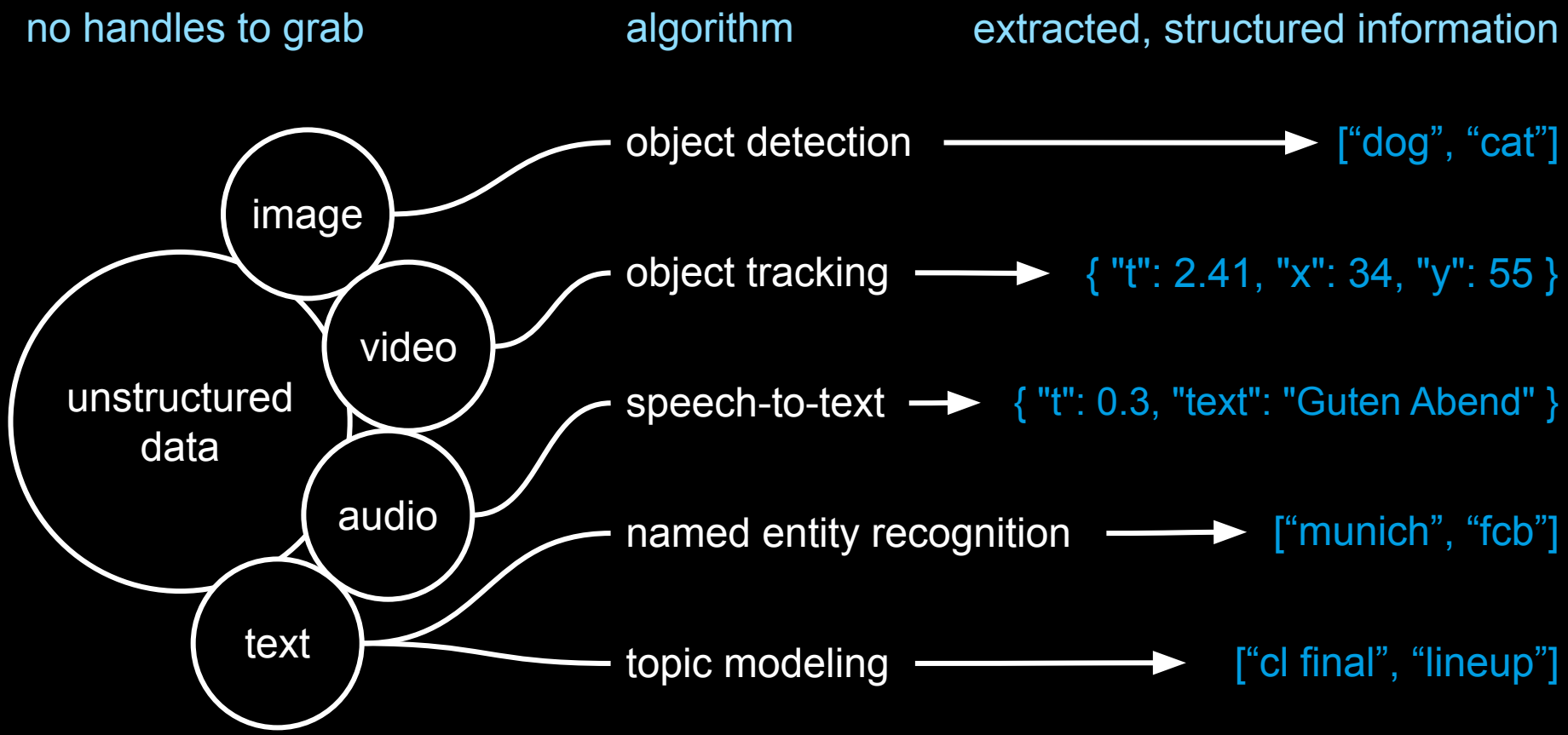


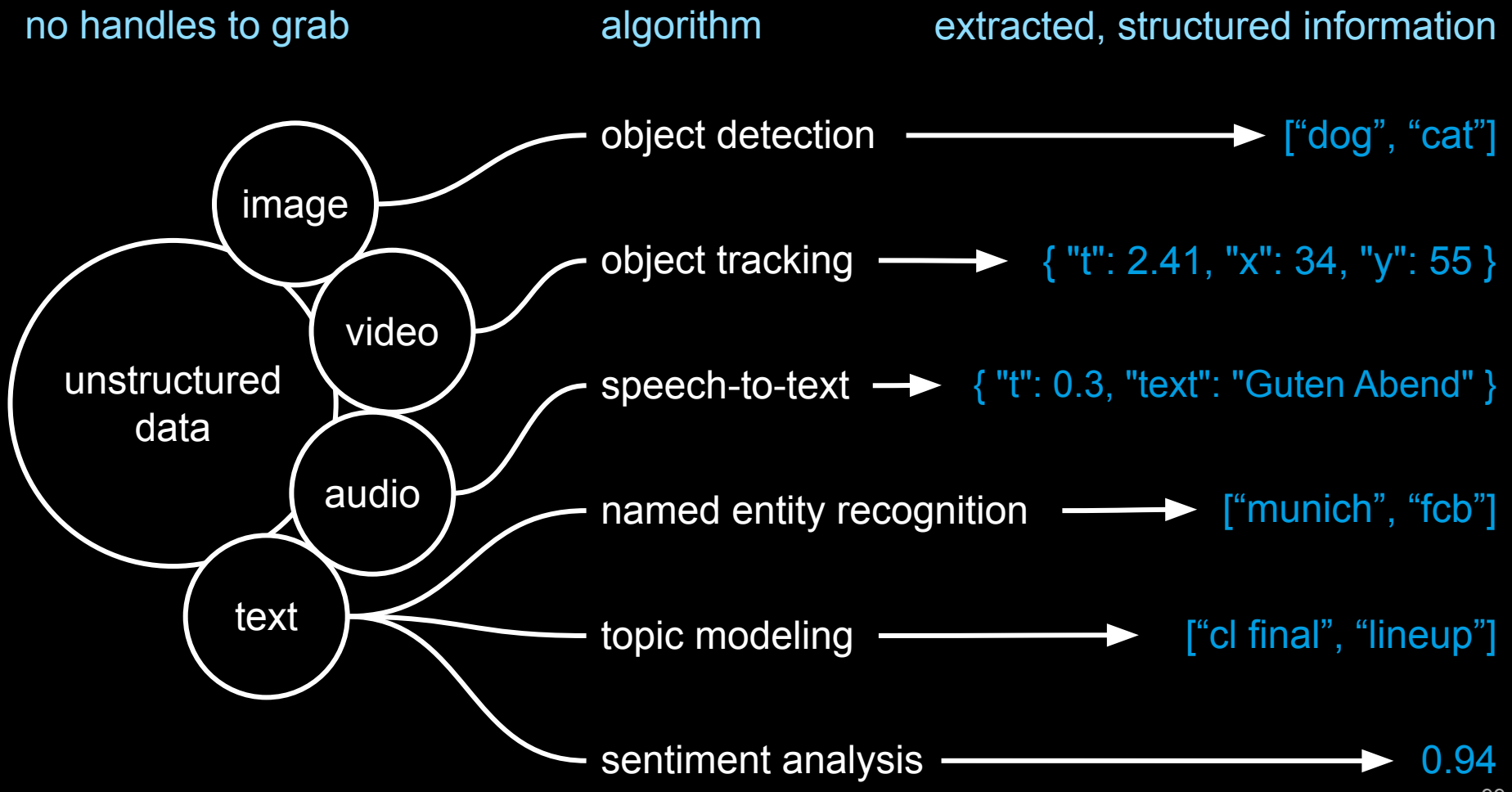

object detection → ["dog", "cat"]

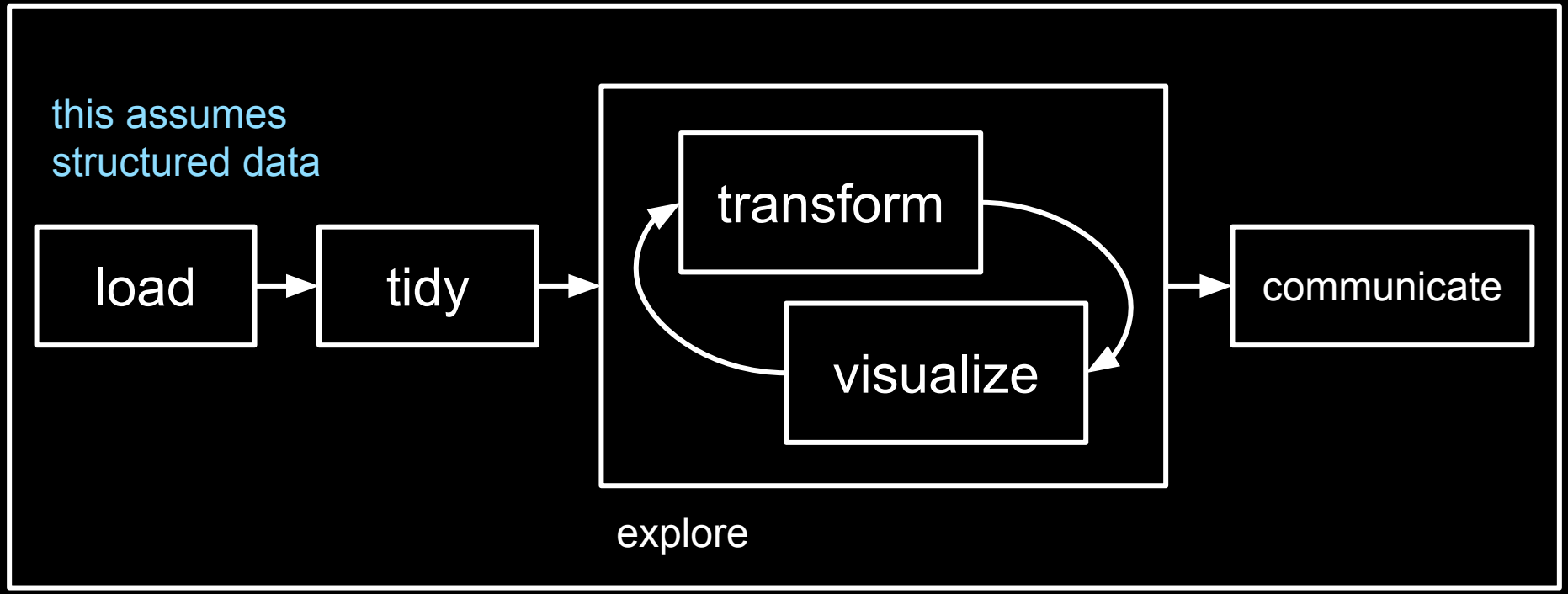
object tracking → { "t": 2.41, "x": 34, "y": 55 }

speech-to-text → { "t": 0.3, "text": "Guten Abend" }

named entity recognition → ["munich", "fcb"]

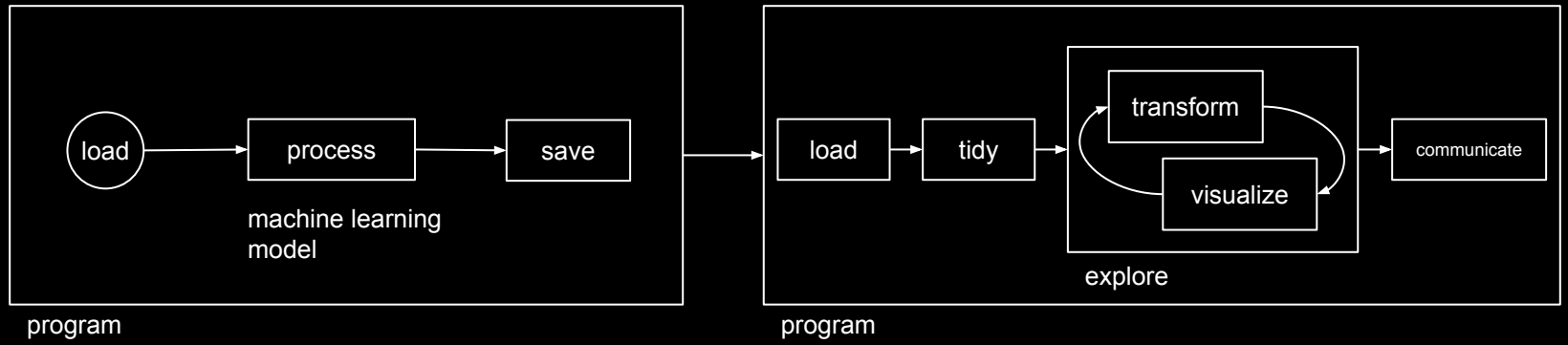

no handles to grab
algorithm
extracted, structured information
image
video
audio
text
unstructured data
object detection
["dog", "cat"]
object tracking
{ "t": 2.41, "x": 34, "y": 55 }
speech-to-text
{ "t": 0.3, "text": "Guten Abend" }
named entity recognition
["munich", "fcb"]
topic modeling
["cl final", "lineup"]


no handles to grab
algorithm
extracted, structured information
image
video
audio
text
unstructured data
object detection
["dog", "cat"]
object tracking
{ "t": 2.41, "x": 34, "y": 55 }
speech-to-text
{ "t": 0.3, "text": "Guten Abend" }
named entity recognition
["munich", "fcb"]
topic modeling
["cl final", "lineup"]
sentiment analysis
0.94


this assumes
structured data
load
tidy
transform
visualize
explore
communicate
program

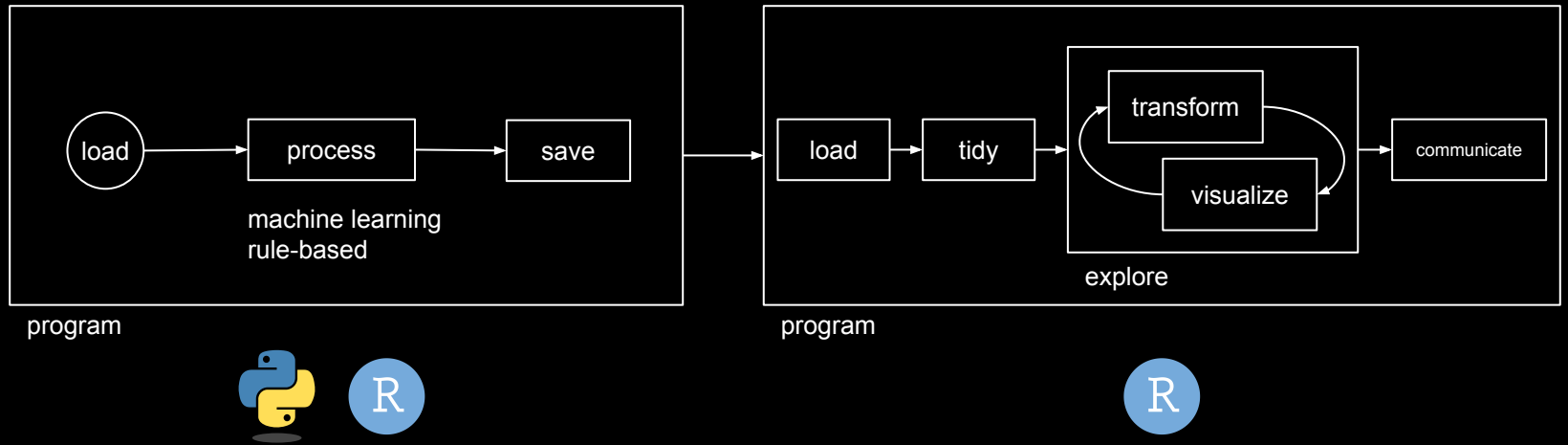
pre-process
unstructured data

exploratory data
analysis



## pre-process unstructured data

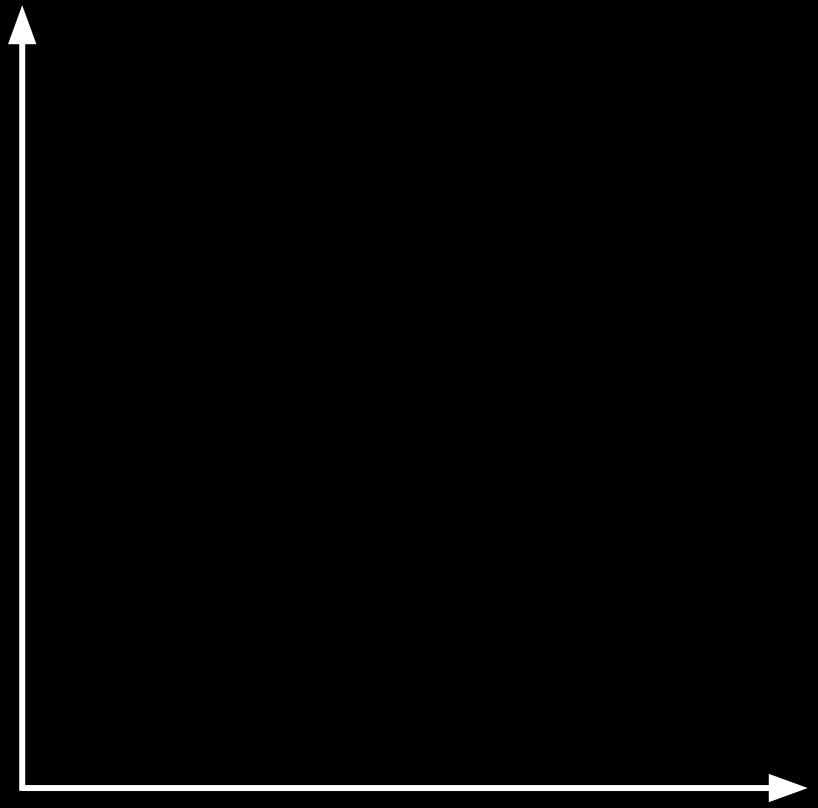
## exploratory data analysis

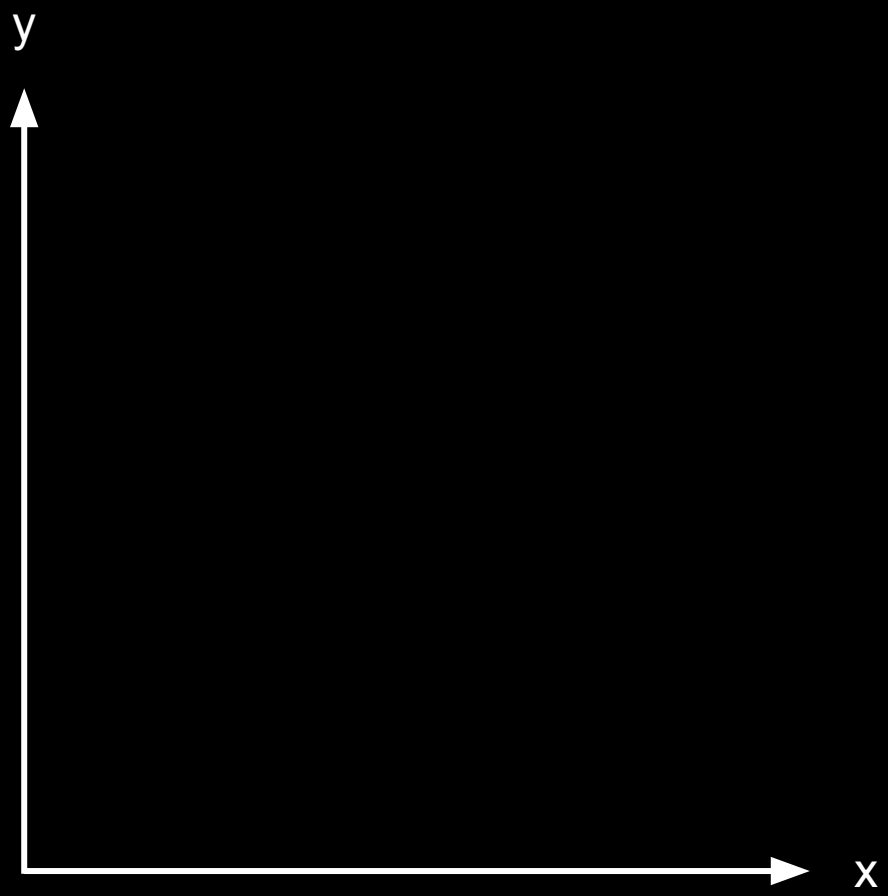


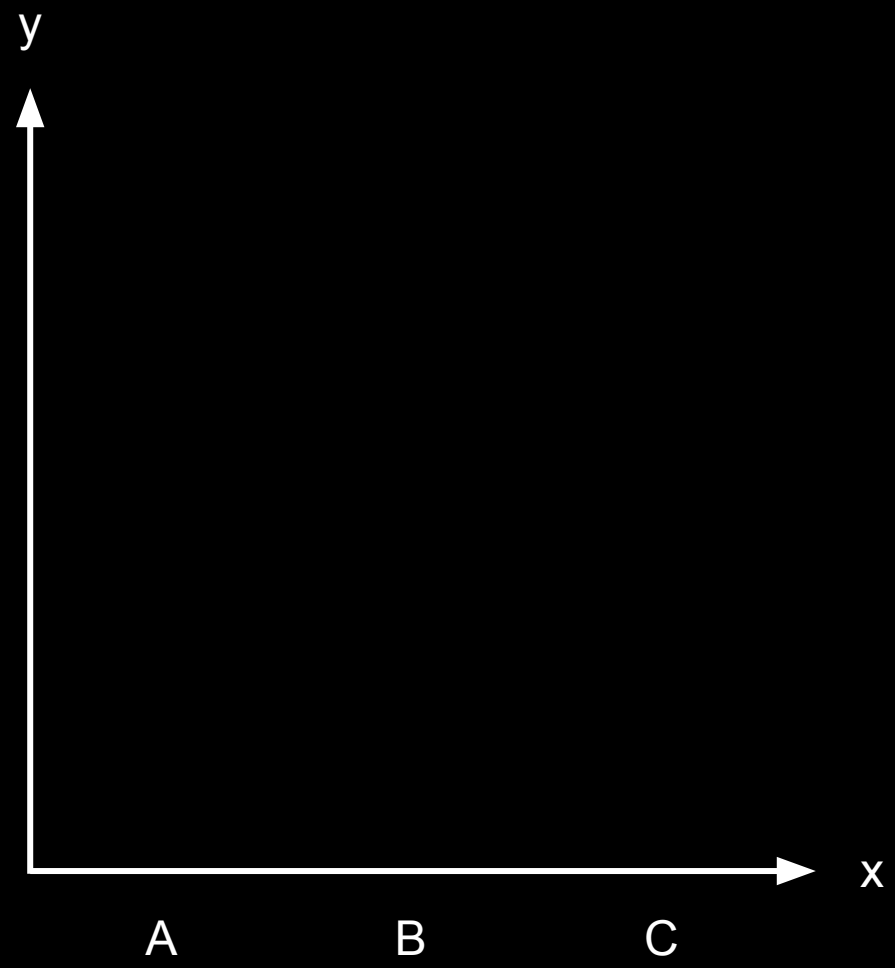
# VISUALIZE DATA

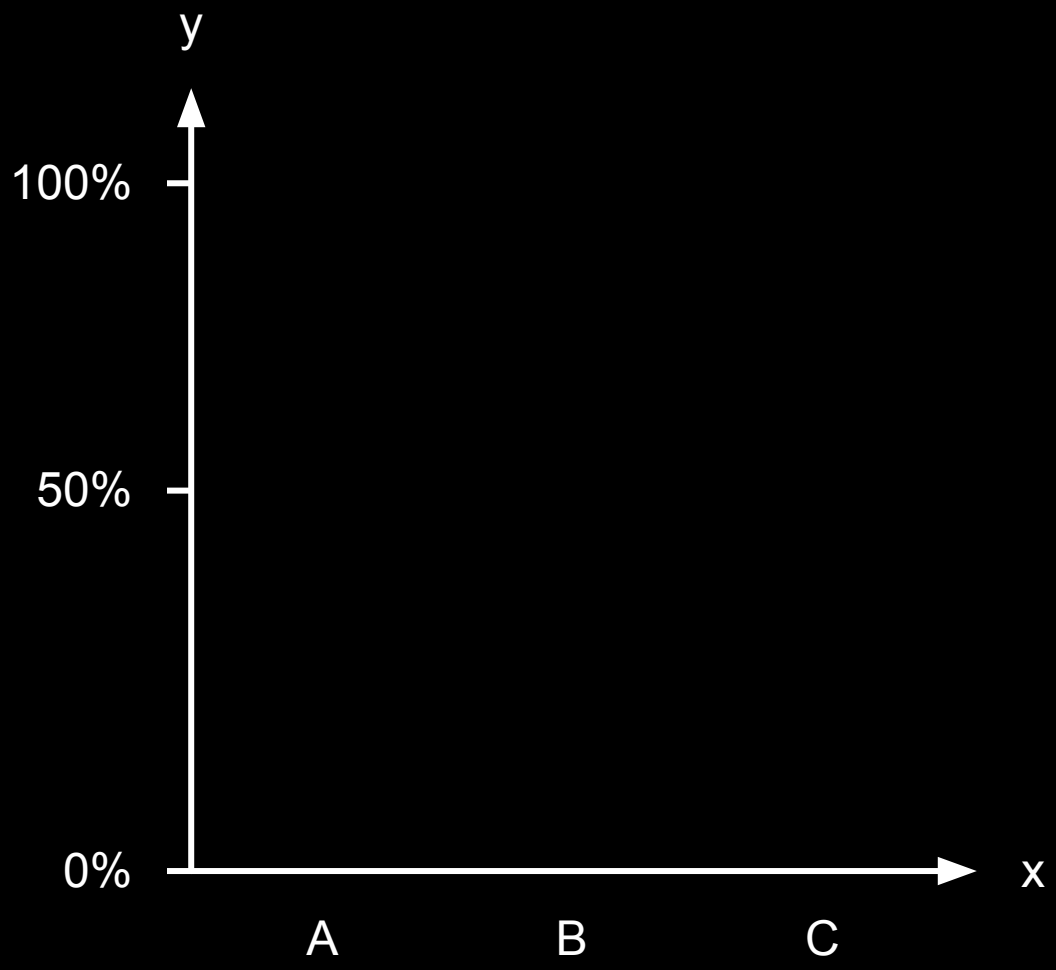
# data

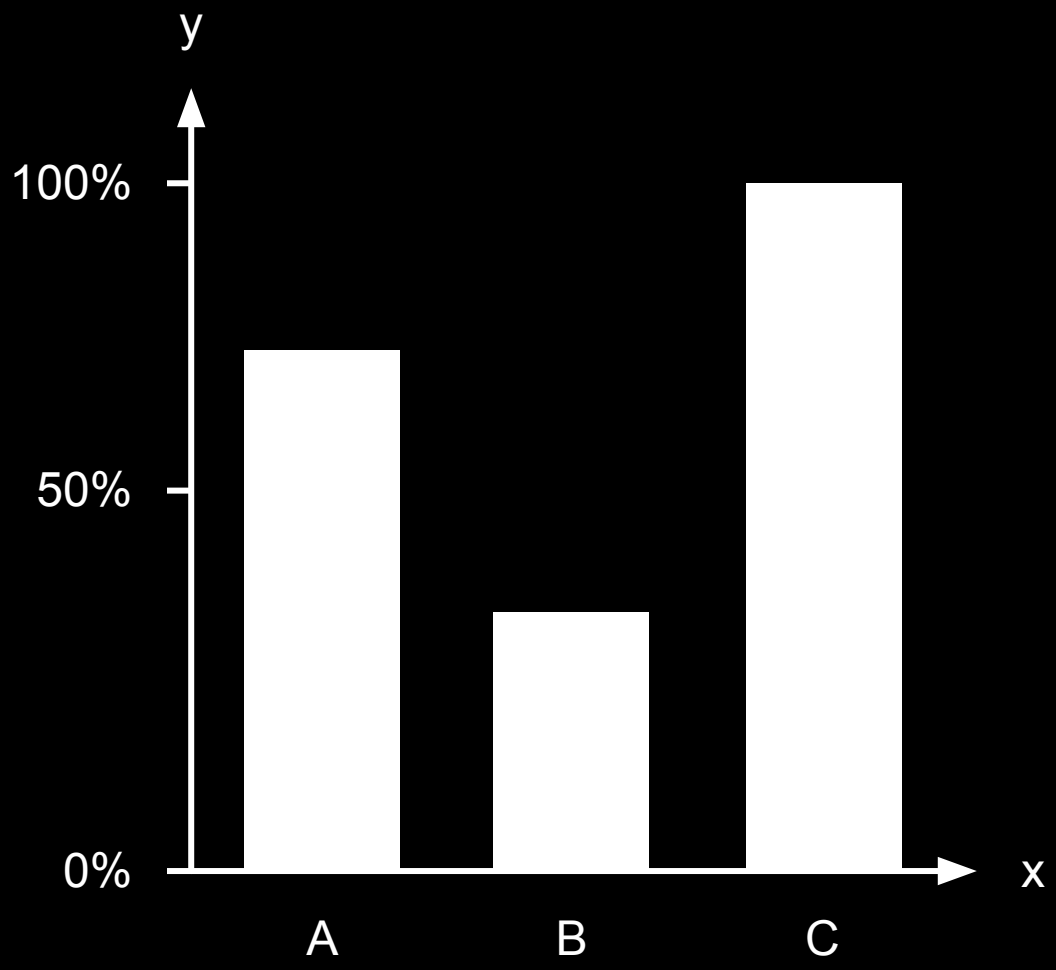
| category | pct |
| --- | --- |
| A | 75 |
| B | 33 |
| C | 100 |



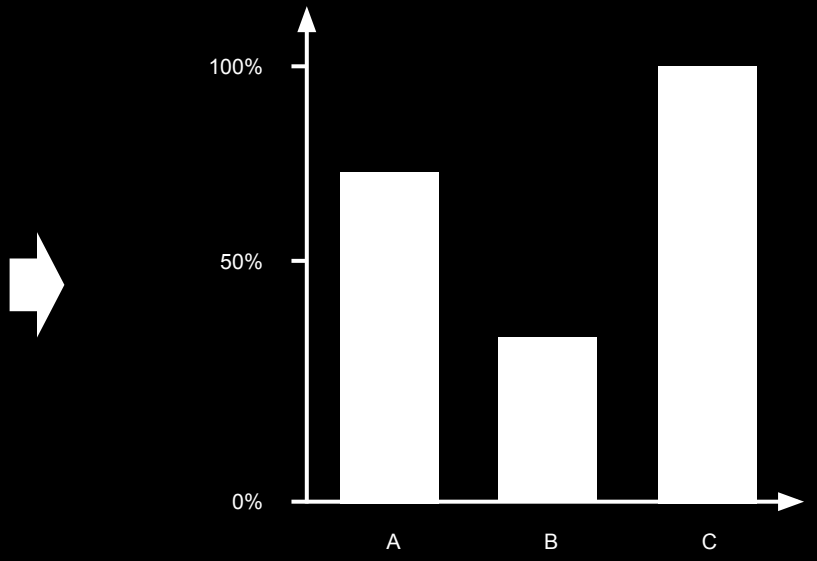

y
x


y
x
A
B
C


y
100%
50%
0%
x
A
B
C


y
100%
50%
0%
x
A
B
C

| category | pct |
| --- | --- |
| A | 75 |
| B | 33 |
| C | 100 |



{{ ggplot2 }}

# why visualize?

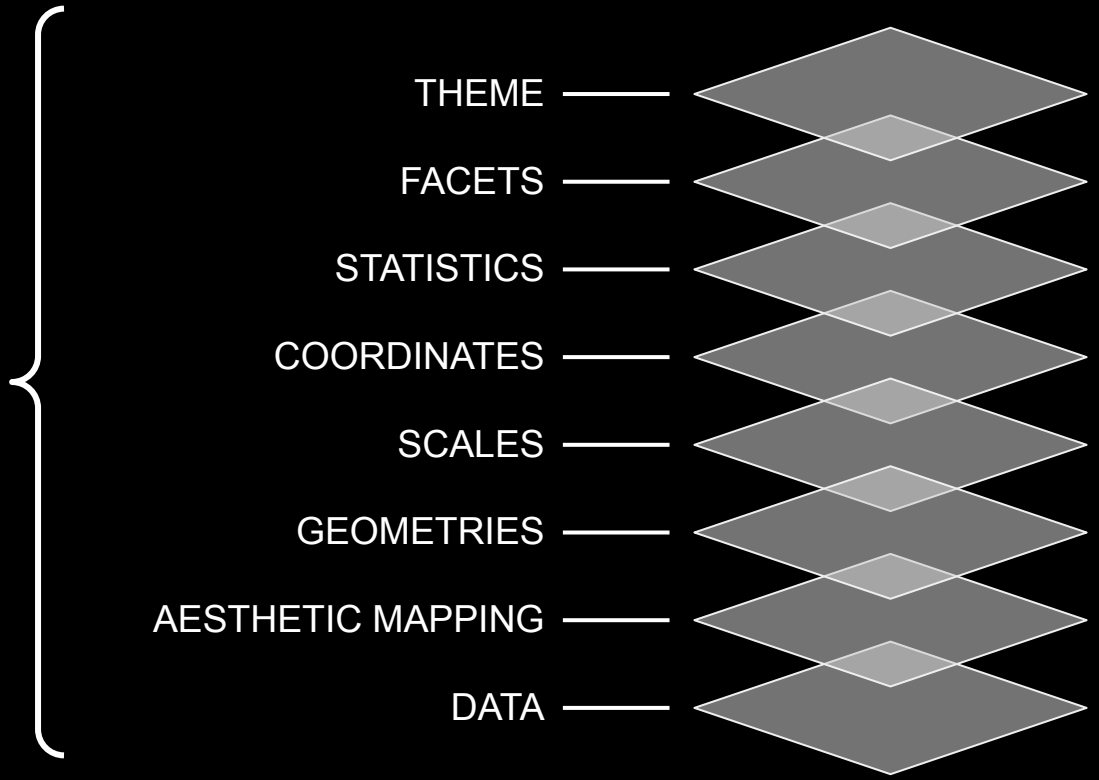
{{ ggplot2 }}

grammar of graphics

any

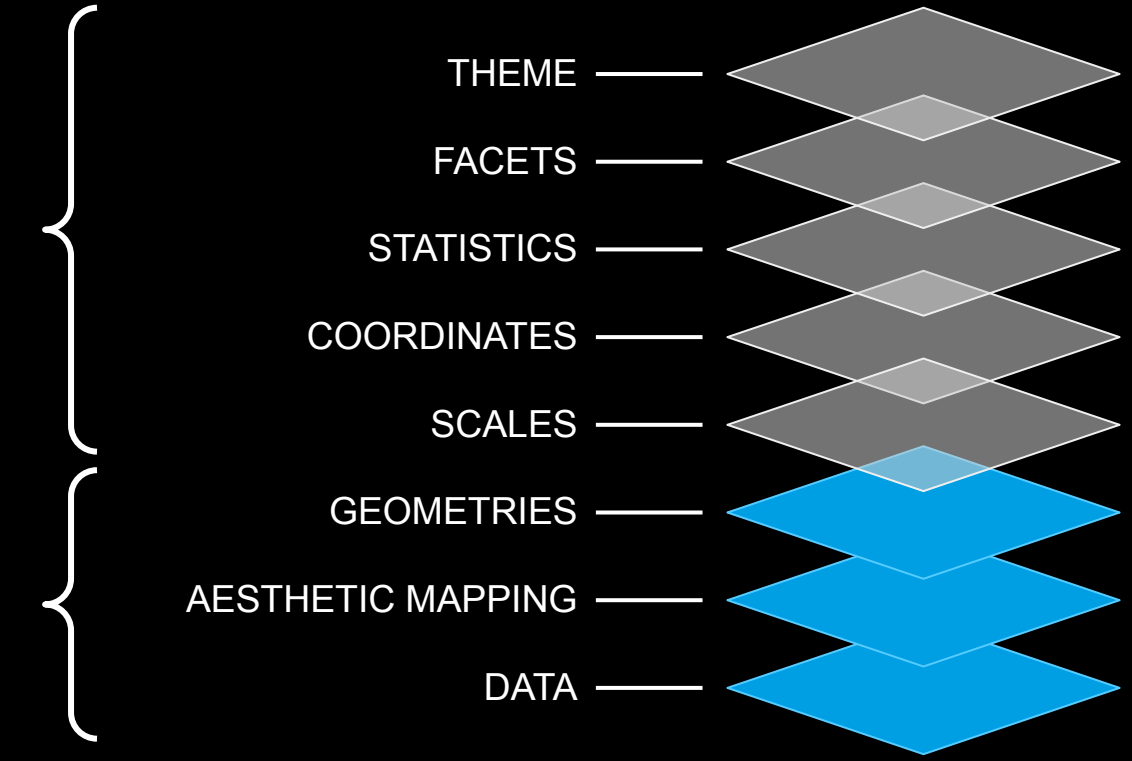
data

visualization



has useful defaults

mandatory

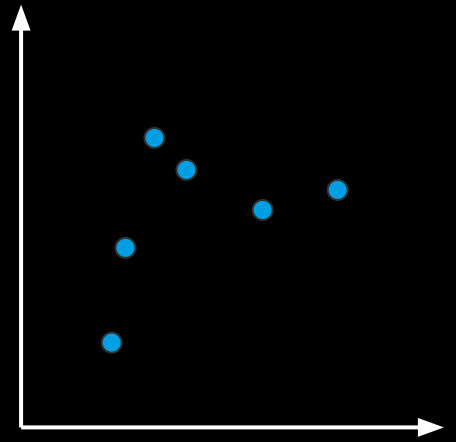


# ggplot()

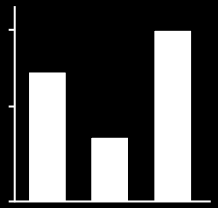
```
ggplot() +
  aes()
```

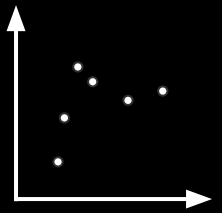
```
ggplot() +
  aes() +
  geom_point()
```

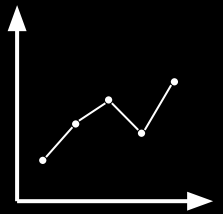
```
ggplot() +
  aes() +
  geom_point()
```

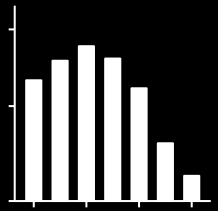


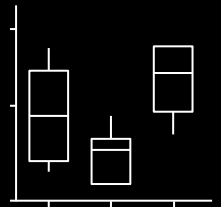
# basic plots

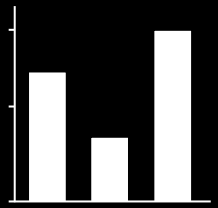




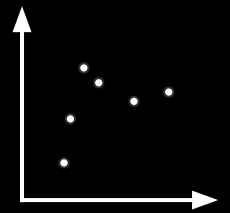




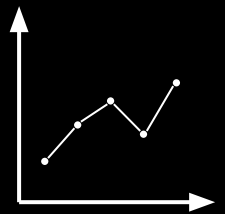




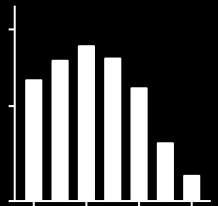
bar chart



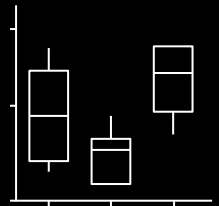
scatter plot



line chart

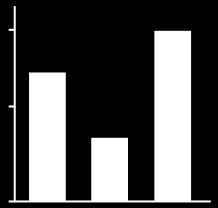


histogram



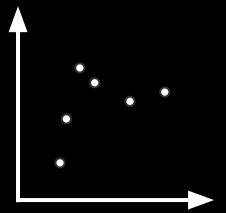
box plot

amounts
proportions
distributions (discrete)



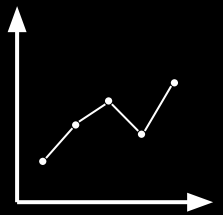
bar chart

associations
patterns



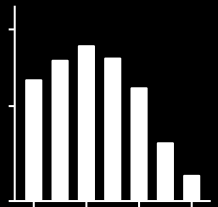
scatter plot

trends
developments



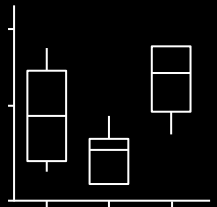
line chart

distributions (continuous)



histogram

compare distributions (continuous)



box plot

# COMMUNICATE FINDINGS

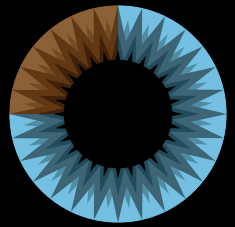
# Quarto

# PYTHON

{{ reticulate }}

# MACHINE LEARNING

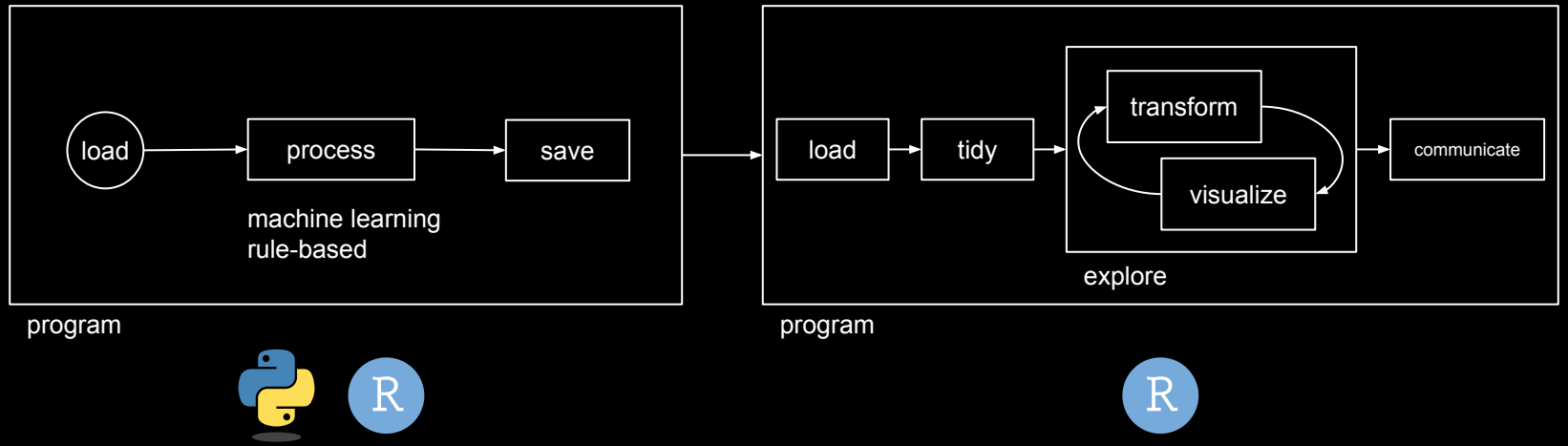
Highly recommended for background information



3Blue1Brown's YouTube Course on Neural Networks and Deep Learning

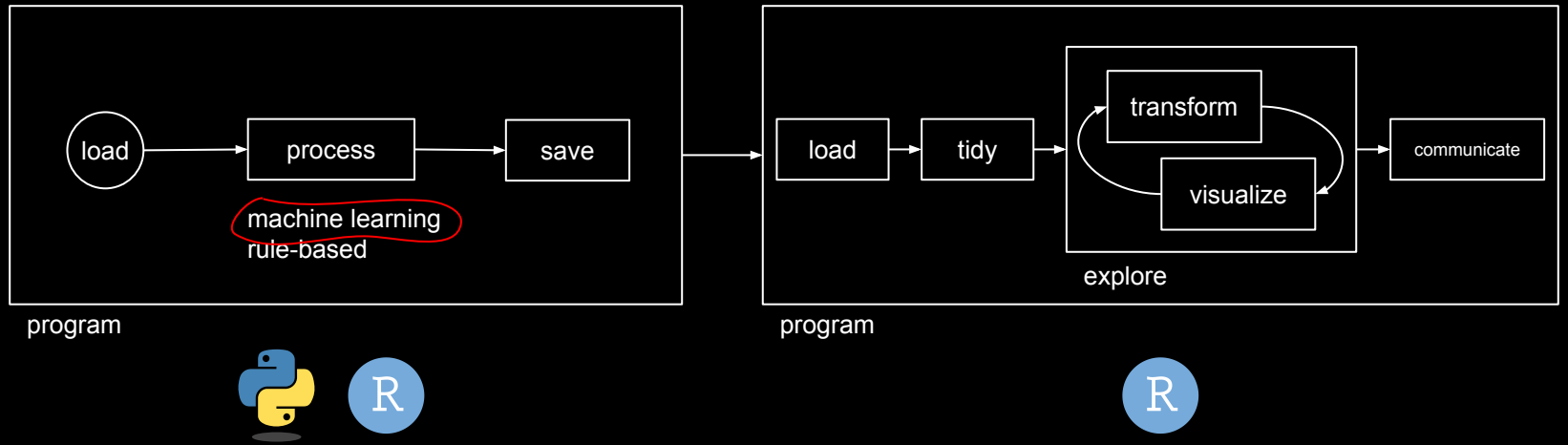
pre-process
unstructured data

exploratory data
analysis

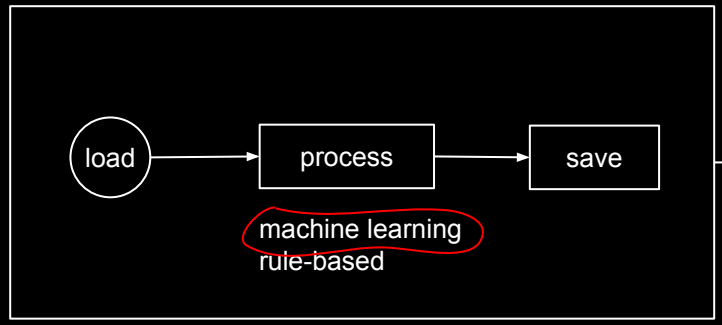


pre-process
unstructured data

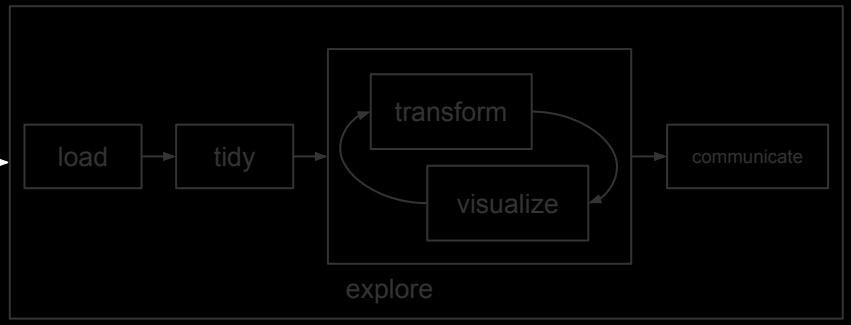
exploratory data
analysis

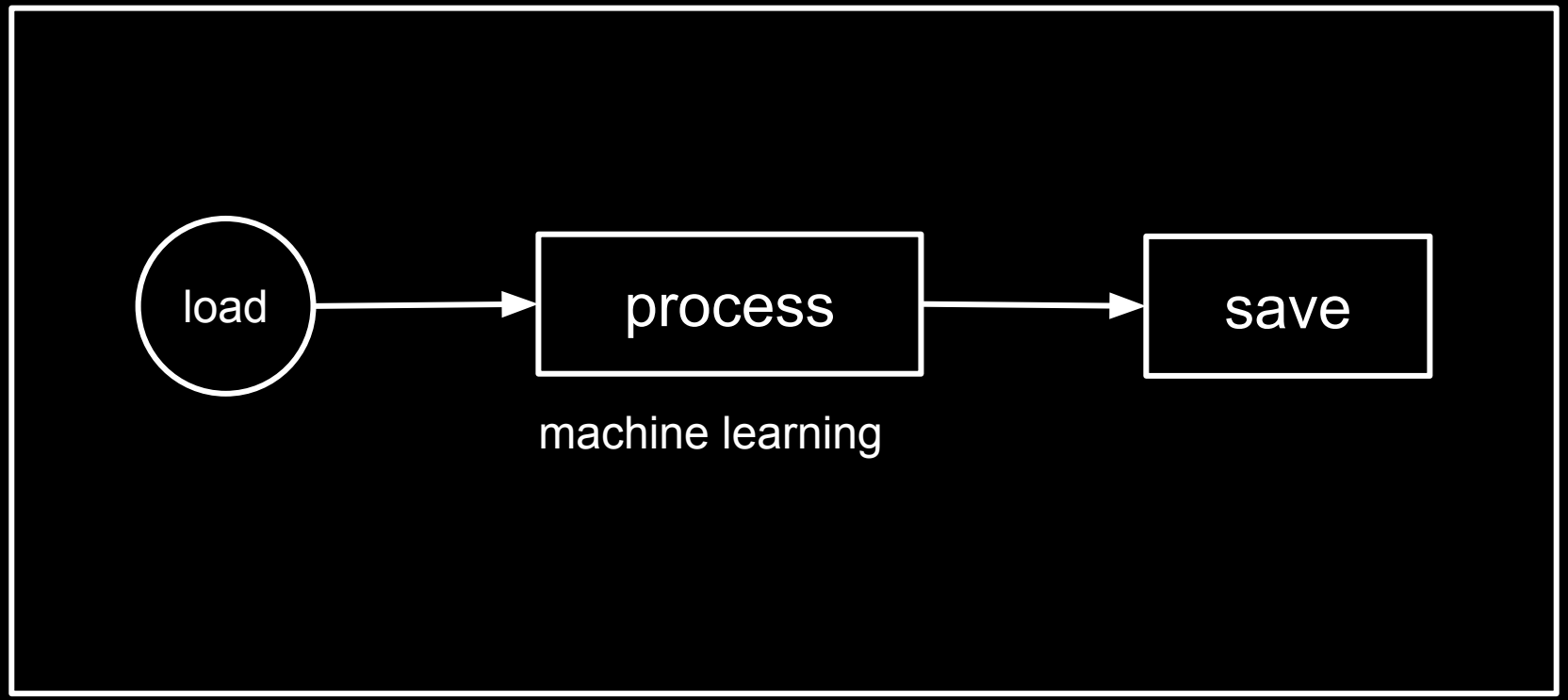


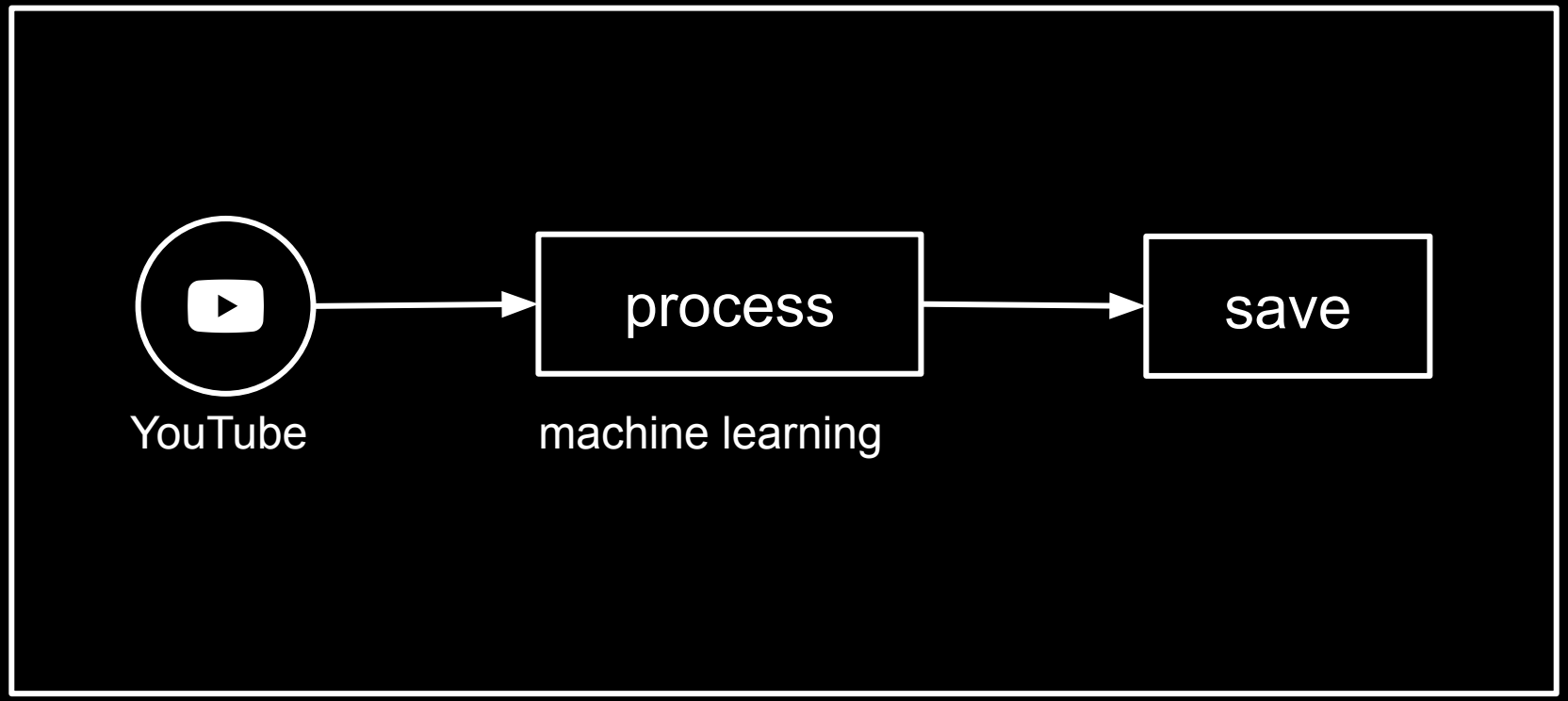
## pre-process unstructured data

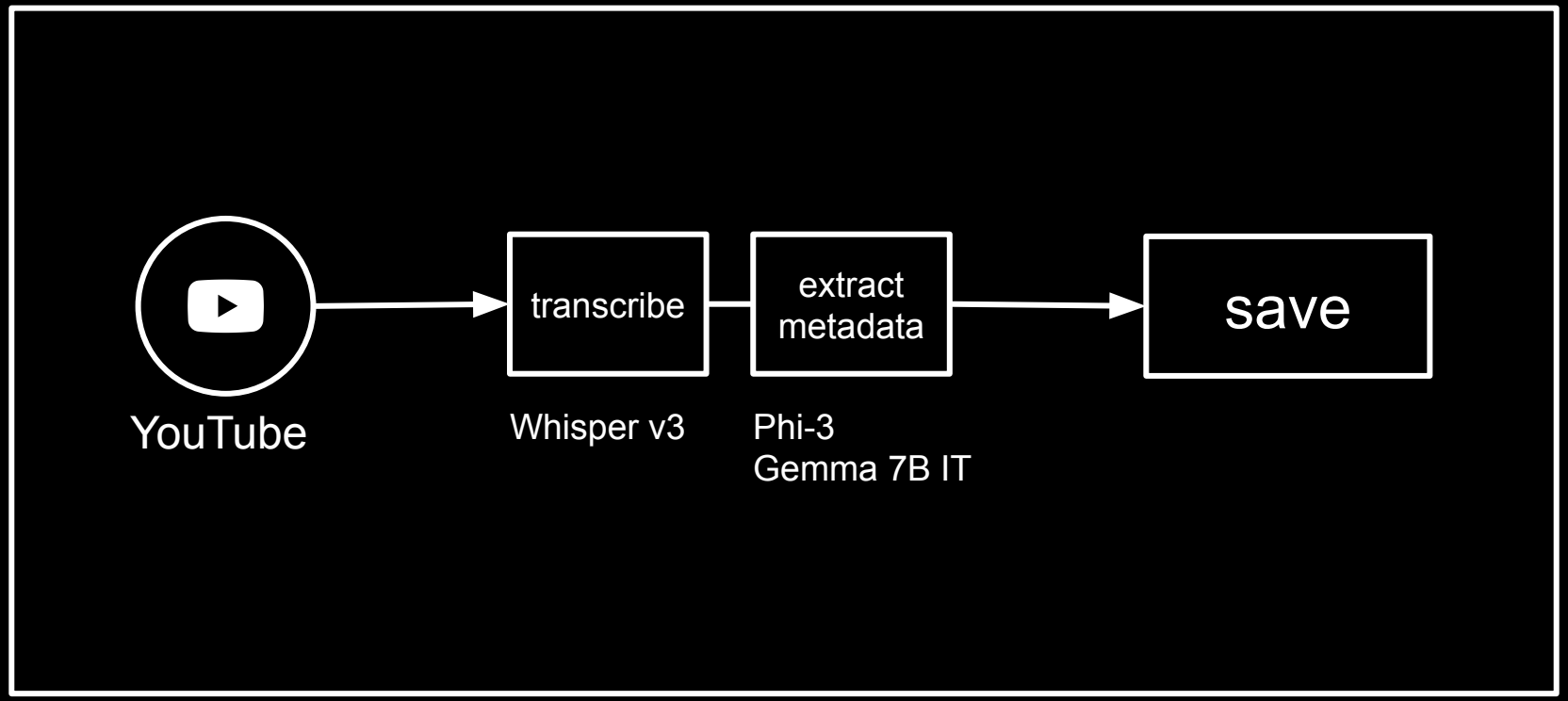


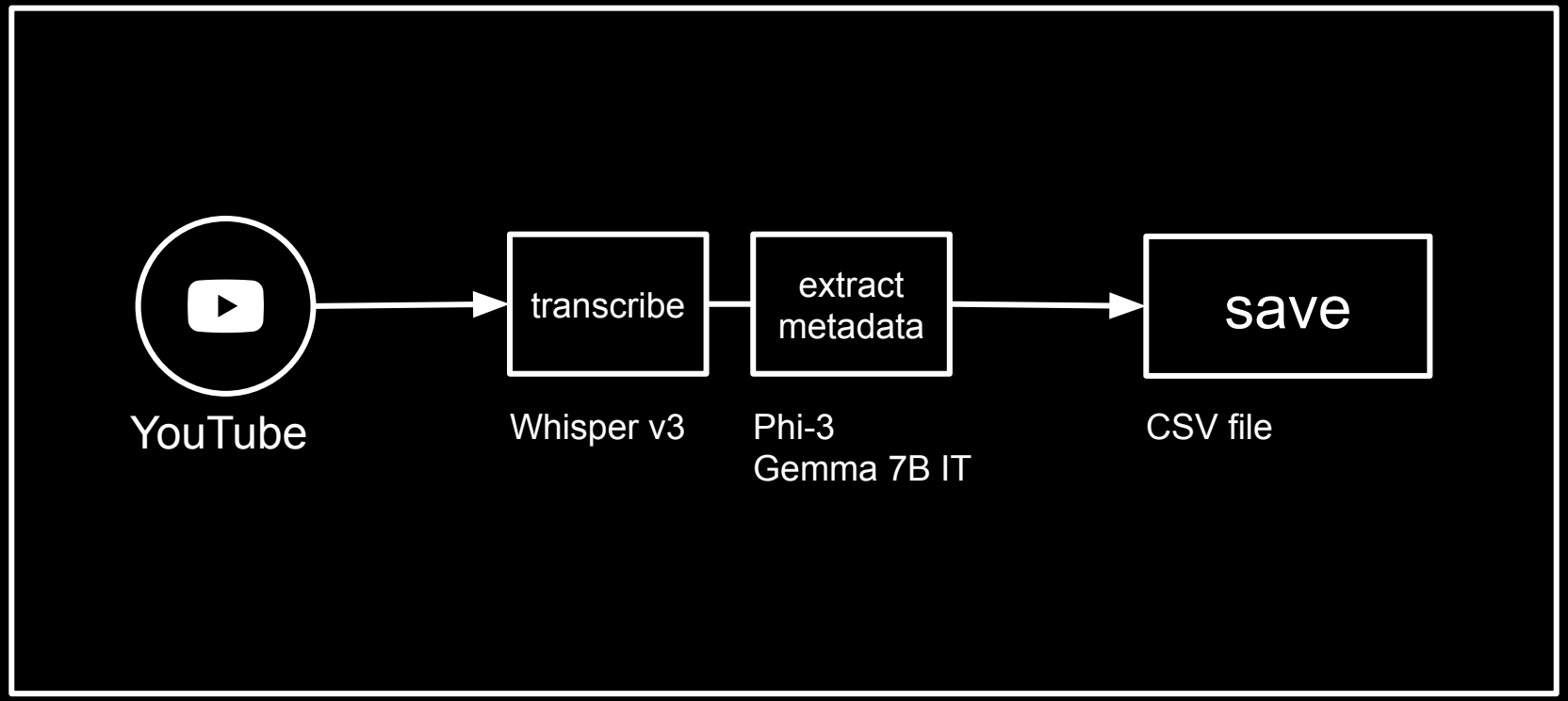
## exploratory data analysis




load
process
save
machine learning
program


process
save
YouTube
machine learning
program


transcribe
extract metadata
save
YouTube
Whisper v3
Phi-3
Gemma 7B IT
program


transcribe
extract metadata
save
YouTube
Whisper v3
Phi-3
Gemma 7B IT
CSV file
program

# YouTube API

# Whisper v3

https://arxiv.org/abs/2212.04356

https://huggingface.co/openai/whisper-large-v3

audio file
whisper v3
transcript

# Large Language Models (LLM)

what has been said so far?

(*prompt / context*)

what has been said so far?
(*prompt / context*)

prediction of next token based on
learnt probability distribution

what has been said so far?
(*prompt / context*)

prediction of next token based on learnt probability distribution

+

(randomness)

what has been said so far?
(*prompt / context*)

prediction of next token based on learnt probability distribution

+

(randomness)

+

(filter)

*(discriminating, insulting content)*

what has been said so far?
(*prompt / context*)

prediction of next token based on
learnt probability distribution

+

(randomness)

+

(filter)

*(discriminating, insulting content)*

next word (*token*)

what has been said so far?
(*prompt / context*)

prediction of next token based on learnt probability distribution

+

(randomness)

+

(filter)

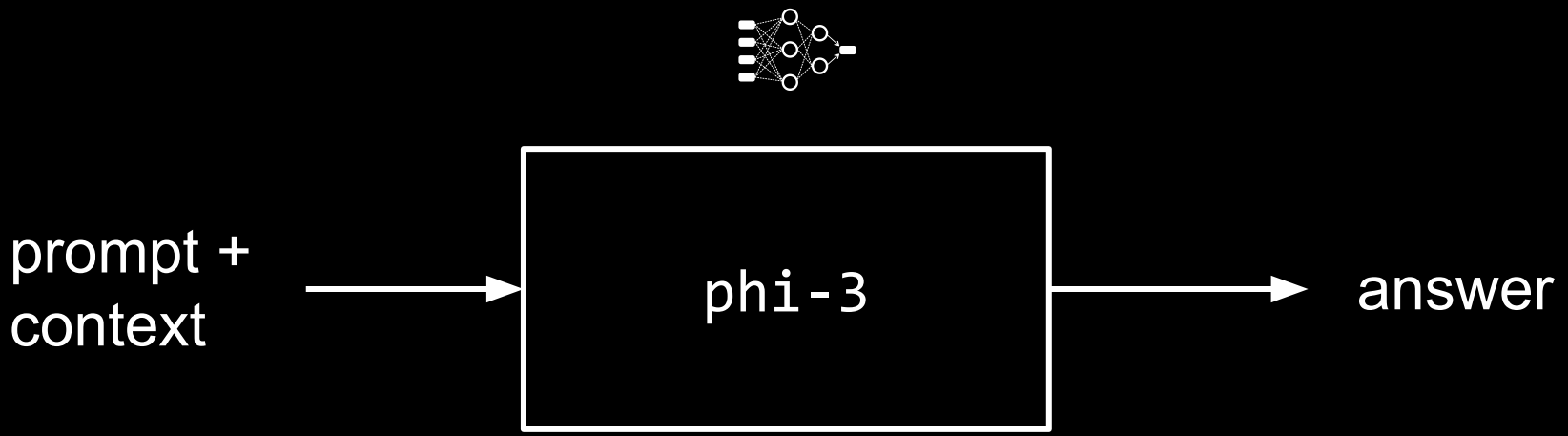
*(discriminating, insulting content)*

next word (*token*)

# Phi-3

https://arxiv.org/abs/2404.14219

https://huggingface.co/microsoft/Phi-3-mini-128k-instruct


prompt +
context
phi-3
answer

# Gemma 2B / 7B Instruct

https://arxiv.org/abs/2403.08295

https://huggingface.co/google/gemma-2b-it

https://huggingface.co/google/gemma-7b-it