DS 5110/CS 5501

Scalable Ray: Sentiment Analysis of Amazon Reviews

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Table of Contents

01 Project Motivation

02 Process

03 EDA & Analysis

04 Results & Conclusion

Project Motivation

User-generated reviews have gained real momentum on e-commerce platforms like Amazon in the 21st century. They contain valuable insights regarding product quality, customer satisfaction, and market trends. Determining market sentiment and assessing unfilled needs is crucial for businesses interested in hidden niches, rich in potential customers. Big data analysis can provide a window into emerging trends and changing consumer preferences.

amazon

Our Data

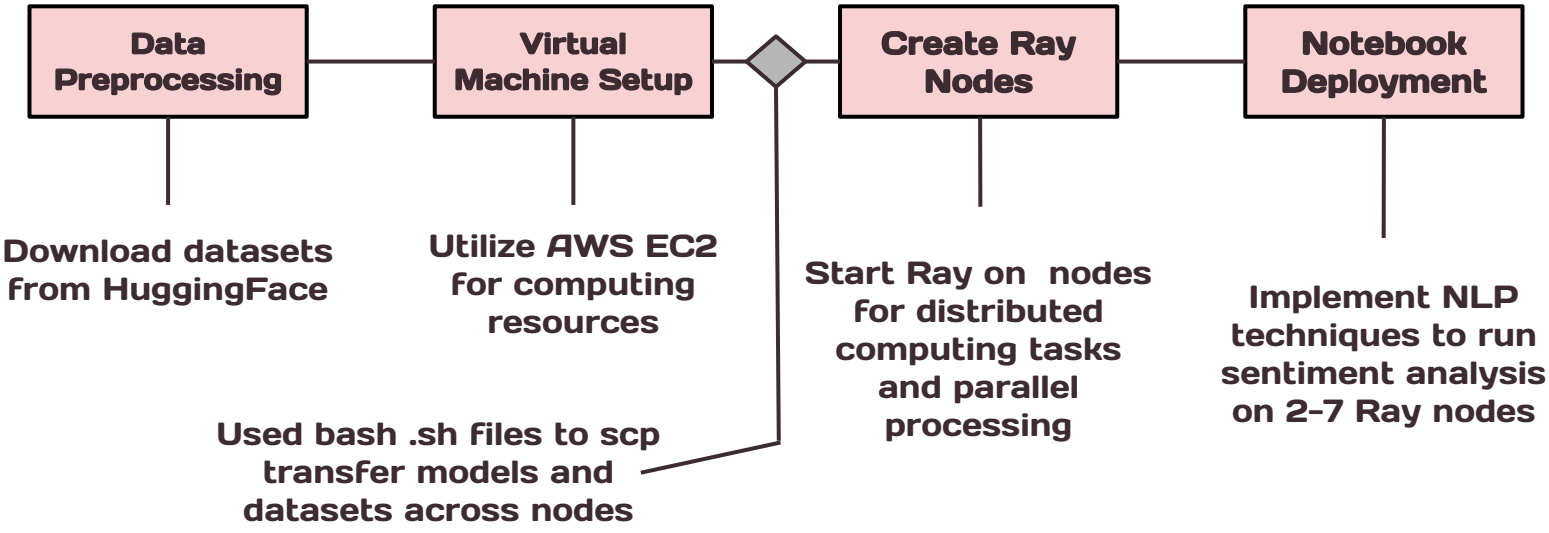
Year	#Review	#User	#Item	#R_Token	#M_Token	#Domain	Timespan
2023	571.54M	54.51M	48.19M	30.14B	30.78B	33	May'96 - Sep'23

Grouped by Category

Category	#User	#Item	#Rating	#R_Token	#M_Token	Download
All_Beauty	632.0K	112.6K	701.5K	31.6M	74.1M	review, meta
Amazon_Fashion	2.0M	825.9K	2.5M	94.9M	510.5M	review, meta
Appliances	1.8M	94.3K	2.1M	92.8M	95.3M	review, meta
Arts_Crafts_and_Sewing	4.6M	801.3K	9.0M	350.0M	695.4M	review, meta
Automotive	8.0M	2.0M	20.0M	824.9M	1.7B	review, meta
Baby_Products	3.4M	217.7K	6.0M	323.3M	218.6M	review, meta
Beauty_and_Personal_Care	11.3M	1.0M	23.9M	1.1B	913.7M	review, meta
Books	10.3M	4.4M	29.5M	2.9B	3.7B	review, meta
CDs_and_Vinyl	1.8M	701.7K	4.8M	514.8M	287.5M	review, meta
Cell_Phones_and_Accessories	11.6M	1.3M	20.8M	935.4M	1.3B	review, meta

- Text data
- # Rows: ~571 million
- We chose categories ~1-2.5 GB: All_Beauty, Appliances, Musical_Instruments, Video_Games
- Random sampling of each dataset

Process Workflow



Using Ray

An open-source framework designed for scaling Python applications from a single computer to a large cluster with ease. Ray is particularly well-suited for machine learning, deep learning, and other data-intensive tasks.

Key features:

- Task Parallelism
- Actor Model
- Scalability and Flexibility

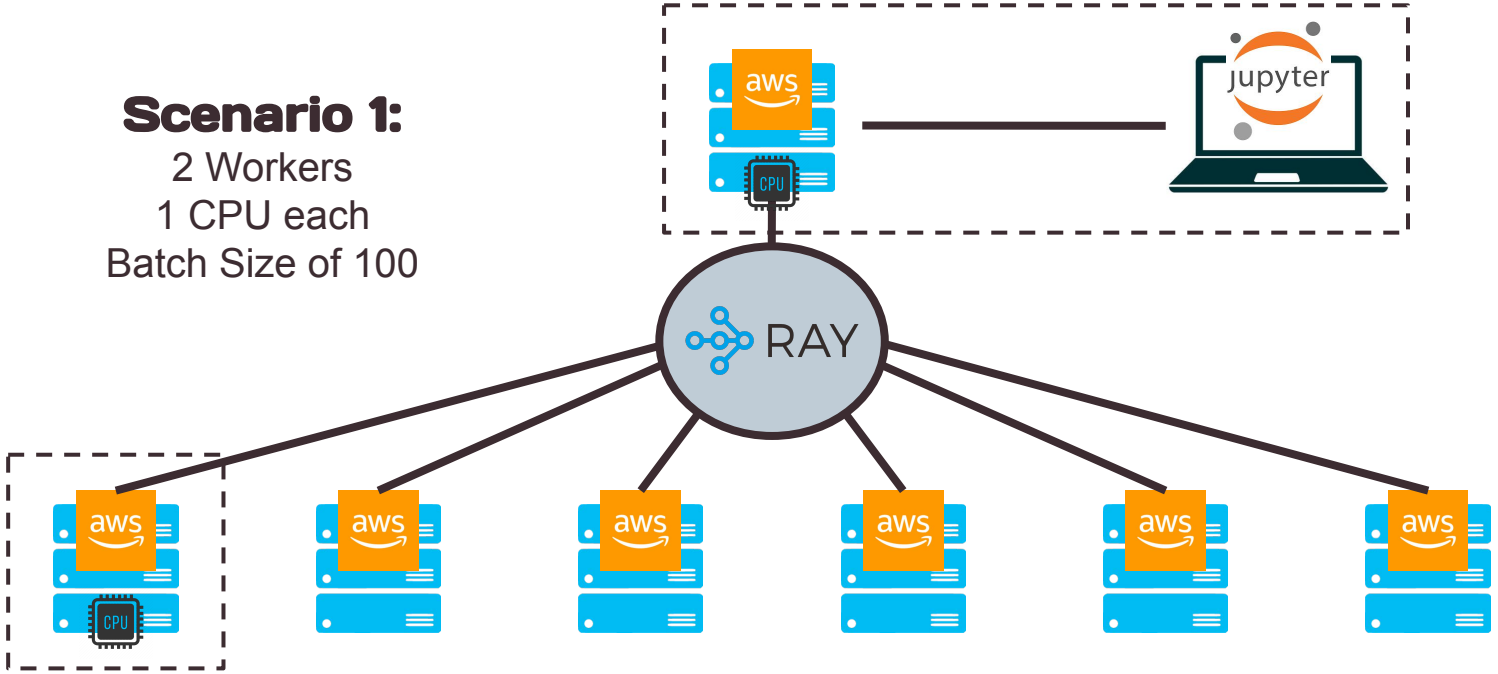
Resources

We used the AWS EC2 services to create our computing infrastructure

- The instance type we used was **t3.large**
  - On-Demand hourly rate: $0.0832
  - vCPU: 2
  - Memory: 8 GiB
- We had **7 instances** total
- **Total cost was ~ $60** at the end of all analysis

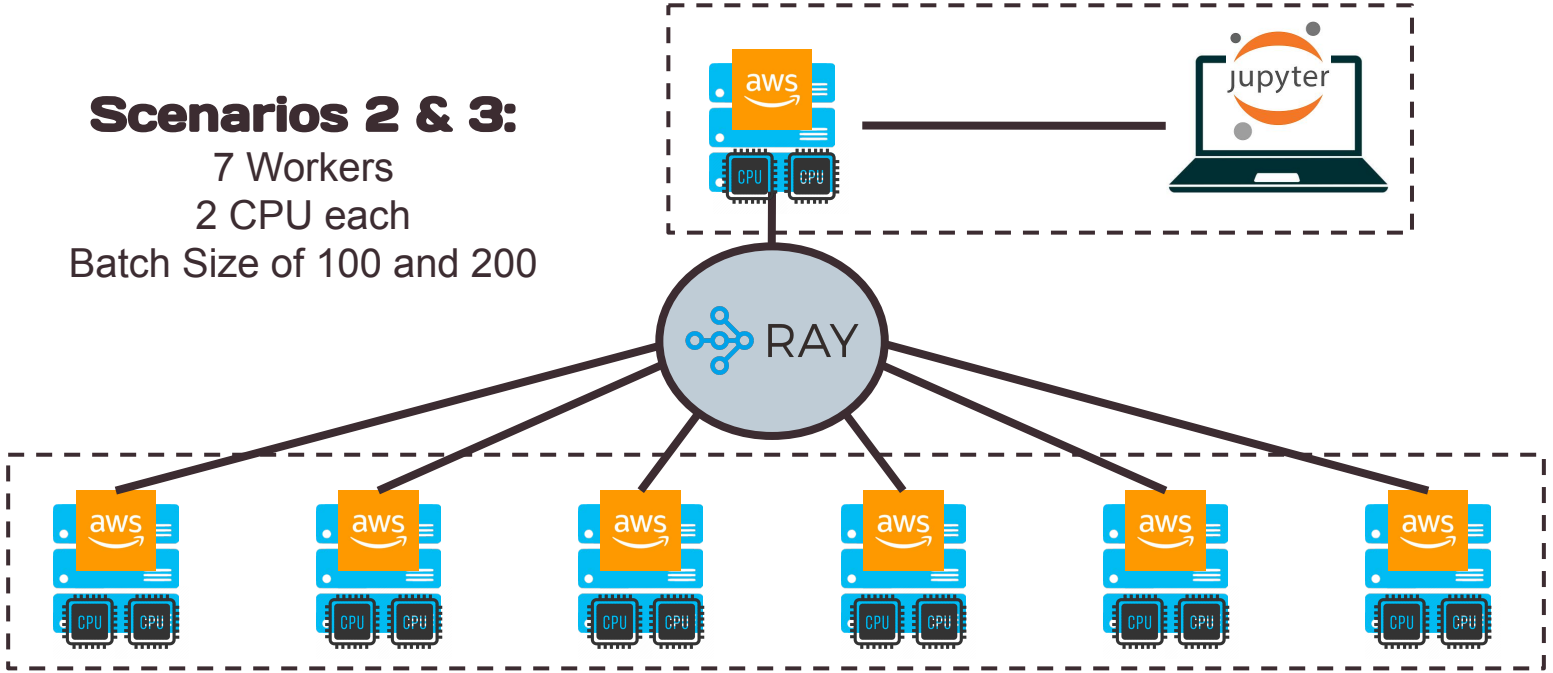
Instance Setup

Scenario 1:
2 Workers
1 CPU each
Batch Size of 100



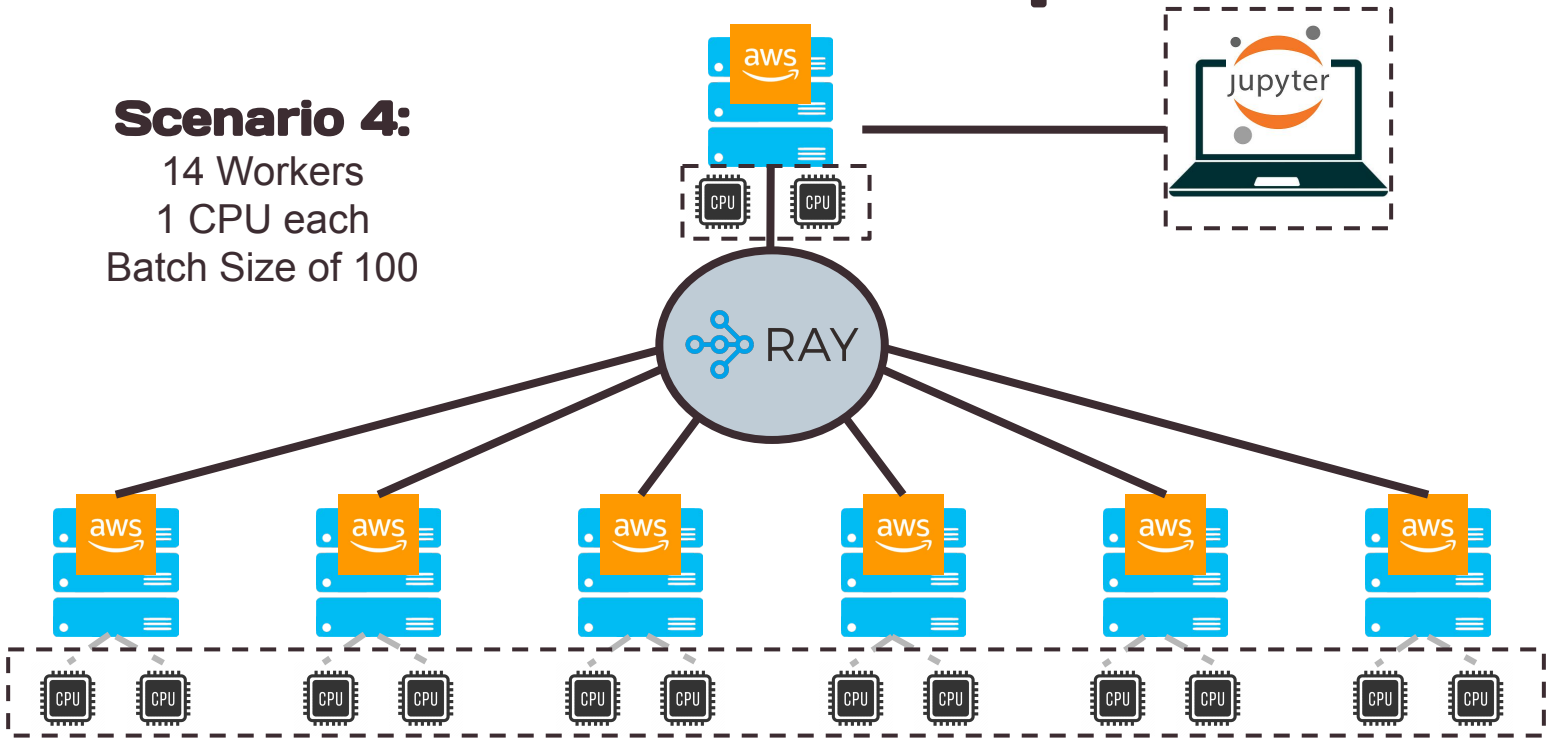
Instance Setup

Scenarios 2 & 3:
7 Workers
2 CPU each
Batch Size of 100 and 200



Instance Setup

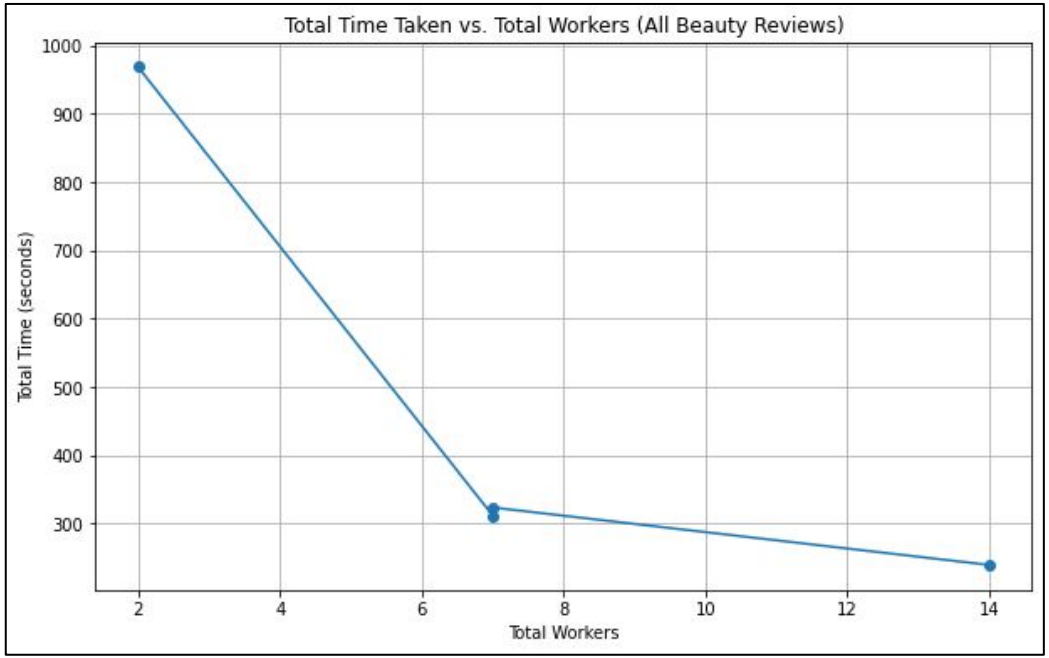
Scenario 4:
14 Workers
1 CPU each
Batch Size of 100



‘All Beauty’ Cluster Performance

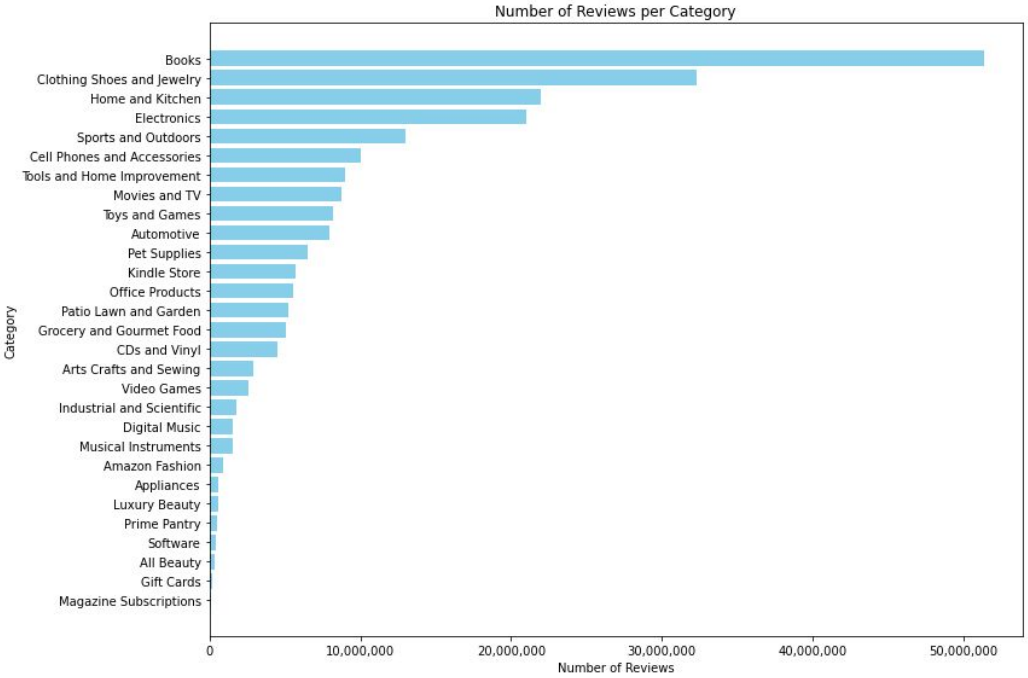
Total Workers	CPUs per Worker	Batch Size	Total Time (s)	Avg. Time per Batch (s)	Avg. Time per Text (s)
2	1	100	968.61	9.5	0.049
7	2	100	312.15	9.42	0.015
7	2	200	323.85	18.82	0.016
14	1	100	239.81	14.54	0.012

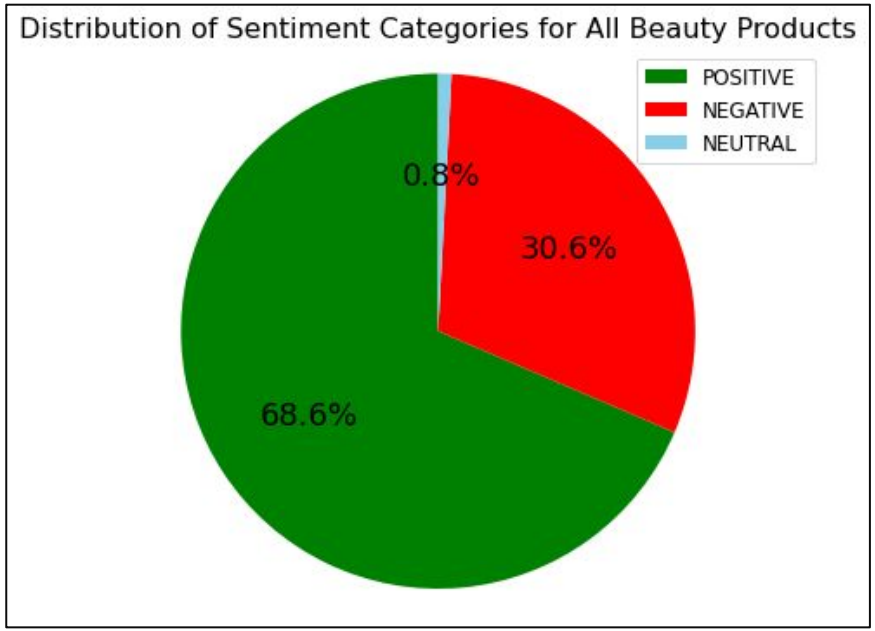
Ray Performance Results

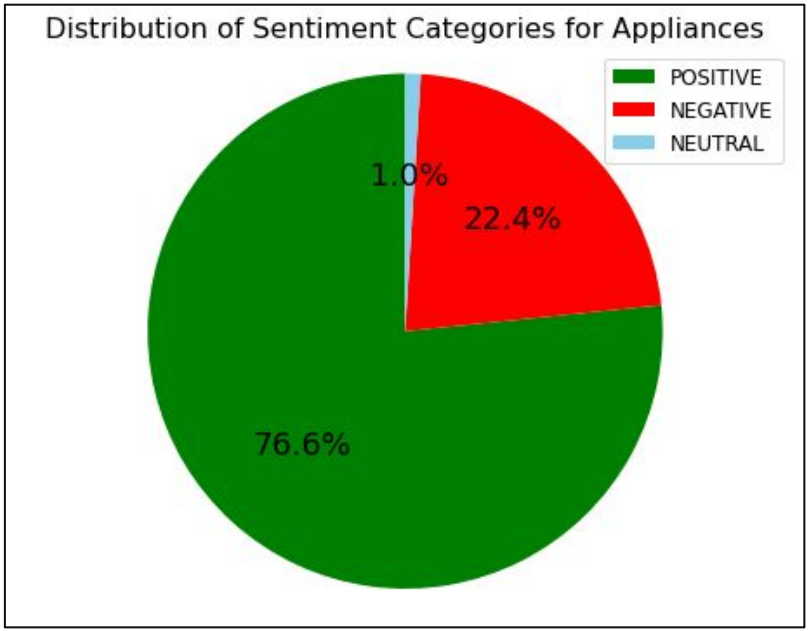


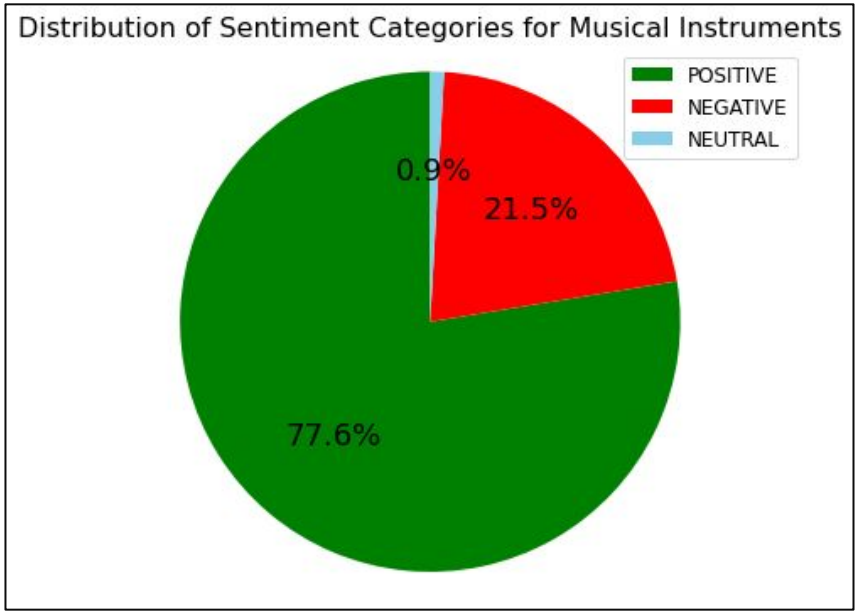
As we increased the number of workers, our **processing time decreased substantially**

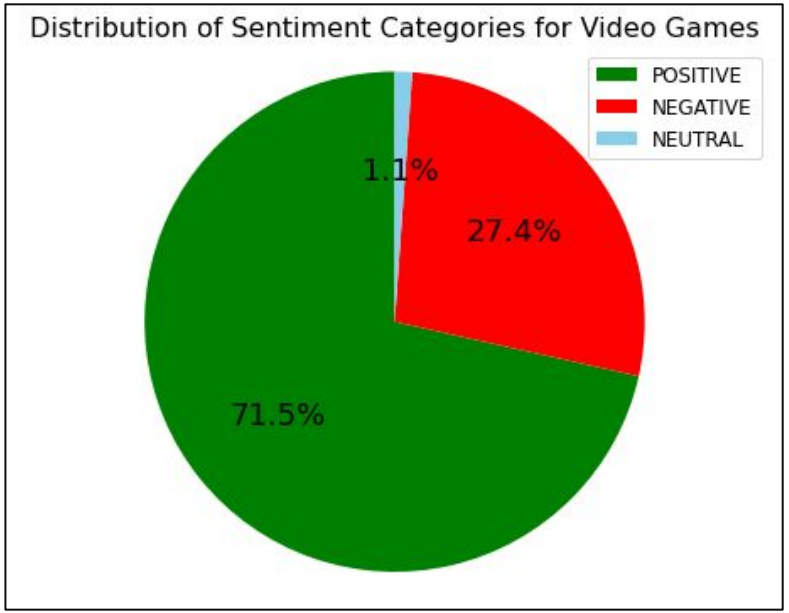
Exploratory Data Analysis




Distribution of Sentiment Categories for All Beauty Products
POSITIVE
NEGATIVE
NEUTRAL
0.8%
30.6%
68.6%


Distribution of Sentiment Categories for Appliances
POSITIVE
NEGATIVE
NEUTRAL
1.0%
22.4%
76.6%


Distribution of Sentiment Categories for Musical Instruments
POSITIVE
NEGATIVE
NEUTRAL
0.9%
21.5%
77.6%


Distribution of Sentiment Categories for Video Games
POSITIVE
NEGATIVE
NEUTRAL
1.1%
27.4%
71.5%

Word Cloud for Negative Sentiment in All Beauty Products

Word Cloud for Negative Reviews in Video Games


Word Cloud for Negative Reviews in Musical Instruments
sound
use
one
guitar
work
string
good
will
product
really
great
mic
time
even
bought
back
used
way
need
play
make
little
stand
thing
better
buy
got
set
much
Amazon
price
microphone
instrument
problem
well
fit
pedal
look
made
around
return
cable
item
bit
tuner
light
box
know
pick
playing
plastic
quality
case
first
money
tried
want
review
speaker
something
tune
screw
note
take
plug
two
put
still
hold
nice
now
cheap
stick
actually
lot
unit
part
ok
came
using
issue
come
thought
find
feel
year
think
right
say
see
bad
headphone
purchased
returned
instruction
never
bass
far
different
piece
volume
going
amp
seem
fine
give
broke
small
go
keep
hard
enough
day
place
easy
less
maybe
though
without
purchase
nothing
keyboard
disappointed
month
hand
star
turn
end
size
new
looking
said
found
strap
device
needed
long
received
quite
hole
sure
music
easily
top
side
people
metal
love
tone
recommend
worth
trying
cost
another
order
ordered
pretty
inside
expected
anything
key
kind
head
everything
wanted
help
loud
either
bridge
noise
probably
pay
almost
week
high
neck
able
getting
worked
recording
might
design
least
audio
instead
overall
last
try
best
cut
bag
many
guess
replacement
heavy

Word Cloud for Negative Reviews in Appliances

Results

We ranked the **four** Amazon categories we investigated in terms of negative review percentage:

1. **Beauty Products** (30.6%)

2. **Video Games** (27.4%)

3. **Appliances** (22.4%)

4. **Musical Instruments** (21.5%)

Results Cont.

Common words/themes included in each negative review category:

1. **Beauty Products:** Hair, Color

2. **Video Games:** Controller, Keyboard

3. **Appliances**: Filter, Fit

4. **Musical Instruments**: Sound, Guitar

Conclusion

We identified a significant market opportunity within the **Beauty products** category, which had the highest percentage of negative reviews expressing dissatisfaction or criticism (30.6%). This indicates a clear demand for higher-quality products particularly in **hair-care,** and suggests a gap in the market that manufacturers can capitalize on.

Limitations/Future Work

- Computational Resources
- Non-text reviews (emojis)
- Year-by-year changes

Thanks!

Do you have any questions?