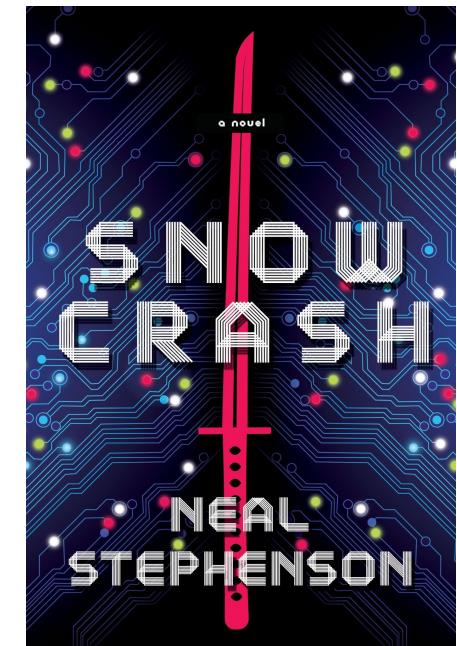


Tower of Babel: Making Apache Spark, Apache Mahout, Kubeflow, and Kubernetes Play Nice

For Kubecon



The tower of babel always makes me think of "Snow Crash" which I call "pizza delivery book" which makes me hungry for pizza. And now you can be hungry for pizza too!



Who am I?

- My name is Holden Karau
- Pronouns are she/her
- Apache Spark PMC (think committer with tenure)
- Contributor to a lot of other projects
- previously Apple, IBM, Alpine, Databricks, Google, Foursquare & Amazon
- co-author of High Performance Spark, Learning Spark, and Kubeflow for Machine Learning
- Twitter: [@holdenkarau](https://twitter.com/@holdenkarau)
- Slideshare <http://www.slideshare.net/hkarau>
- OOS Livestreams: <https://youtube.com/user/holdenkarau>
- Github <https://github.com/holdenk>
- Related Spark Videos <http://bit.ly/holdenSparkVideos>
- These may not be my employers views (they did pay for me to be here) :)
 - Although Netflix is hiring actively, if you're interested please reach out





My co-author (not present, has a new kid at home!)

Trevor Grant

Chicago / Humboldt Park

PMC Chair: Apache Mahout

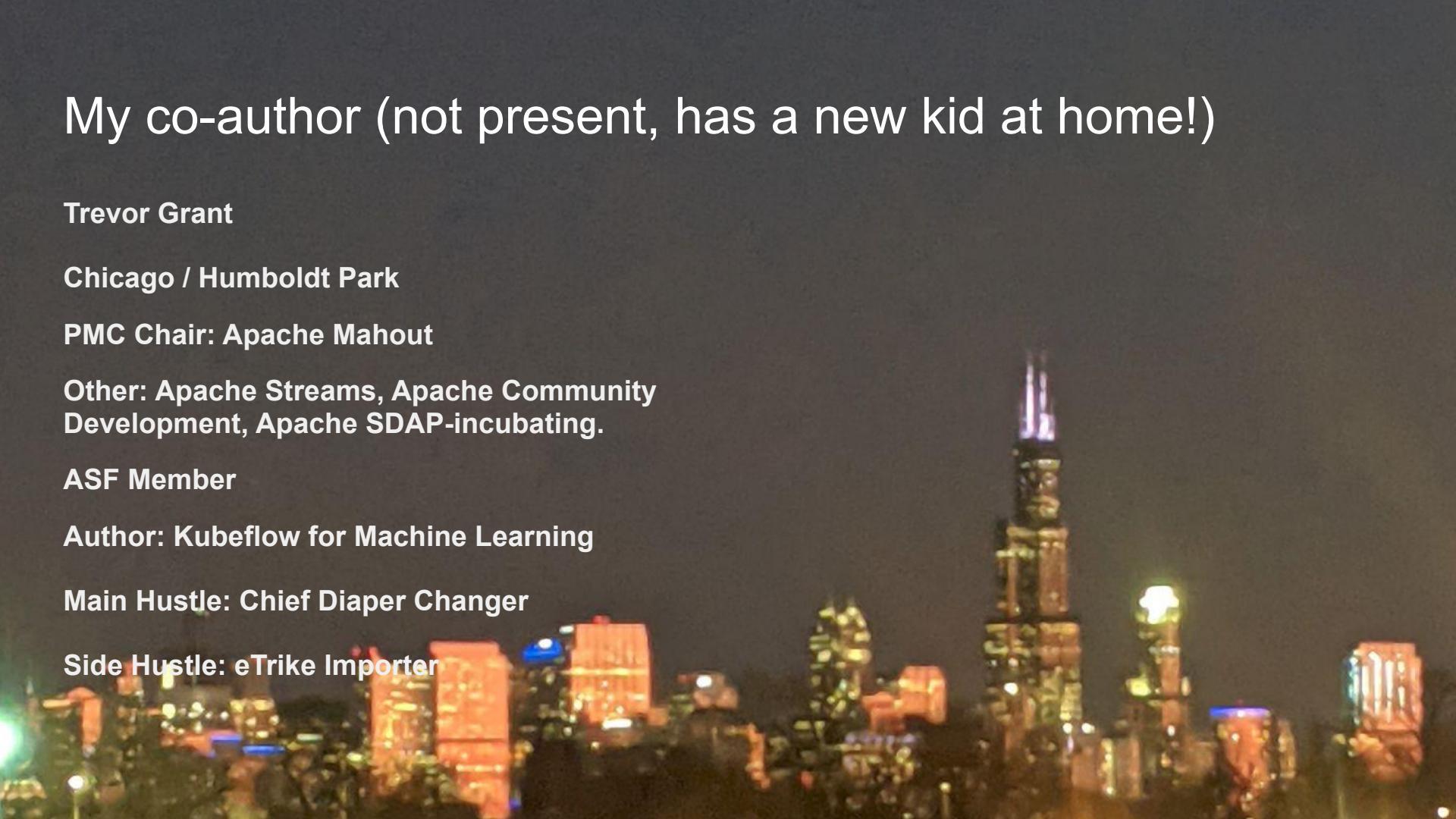
Other: Apache Streams, Apache Community Development, Apache SDAP-incubating.

ASF Member

Author: Kubeflow for Machine Learning

Main Hustle: Chief Diaper Changer

Side Hustle: eTrike Importer



Outline

- The adventure
 - 1st Act: Exposition (Getting to know the characters, and the problem).
 - 2nd Act: The Problem (in more depth)
 - 3rd Act: How we solved it (spoiler- we used Kubeflow)
- Epilogue
 - What (good?) came out of the adventure
 - Some better options for present day (wow tech moves fast)

Act 1: Exposition

Characters

Kubernetes (my 2nd favourite)

Kubeflow (the main character / hiro protagonist*)

Apache Spark (my favourite)

Apache Mahout

*This is a Snow Crash reference and completely optional.

Kubernetes

What is it?

Why do we need it?



Kubernetes

What is it?

Why do we need it?



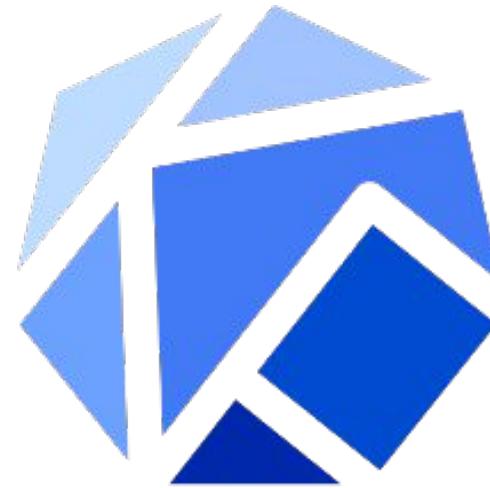
Img Src:

https://www.reddit.com/r/ProgrammerHumor/comments/cw58z7/it_works_on_my_machine/

Kubeflow

What is it?

Why do we need it?

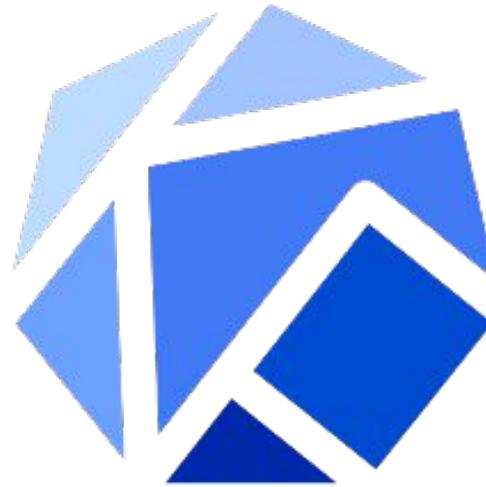


Kubeflow

Kubeflow

What is it?

Why do we need it?



Kubeflow

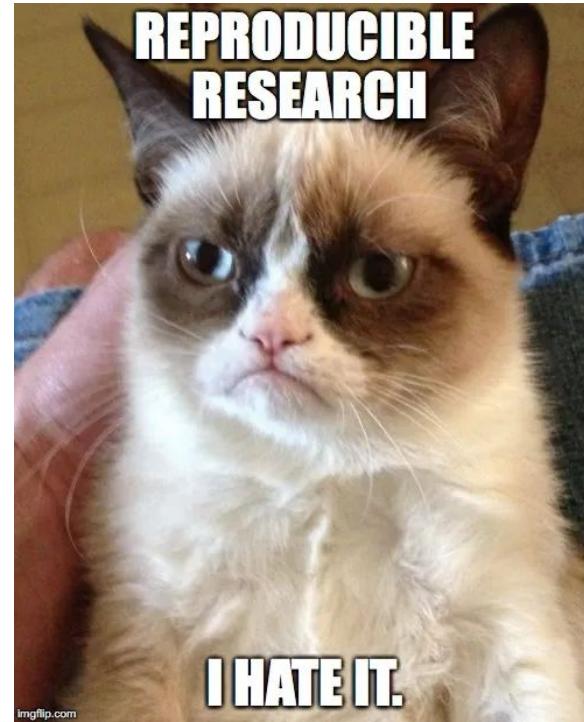
Kubeflow

What is it?

Why do we need it?

Img src:

<https://www.r-bloggers.com/2018/02/reproducible-research-write-your-clinical-chemistry-paper-using-r-markdown/>



Apache Spark

What is it?

Why do we need it?



Apache Spark

What is it?

Why do we need it?



Apache Mahout

What is it?

Why do we need it?



Apache Mahout

What is it?

Why do we need it?



Apache Mahout

What is it?

Why do we need it?

(Email dev-subscribe@mahout.apache.org to get involved)

Img attr: Game of Thrones season 2 episode 3 copyright HBO



Apache Mahout

What is it?

Why do we need it?



The problem: COVID Screening

Bigger problem in early days of COVID (and before rapid tests were available).

Act 2: The plot thickens...

Rapid Testing Needed

Rapid Testing Needed

Mental Time Machine - to March 2020.



Rapid Testing Needed - Desperately

Mental Time Machine - to March 2020.

- No one understands Coronavirus- but hospitals are being overrun and people are dying.

How Spain became a hotspot for coronavirus

By Tim Lister and Claudia Rebaza, CNN

Updated 1:37 PM ET, Sat March 28, 2020



Doctors in Spain use 'desperate' measures to fight coronavirus
02:46



Doctor says 'our empathy has taken a hard hit' during covid surge
01:30



Guest corrects Joe Rogan live on his own show. See his reaction
03:23



How to get your at-home Covid-19 test for free
02:37



Why expert recommends mask to stop spread
03:25

Cordoba, Spain (CNN) — Unseasonably warm weather, Champions League football and other major events, homes on the beach and the café culture: just a few of the factors that may have helped carry an [insidious virus](#) across southern Europe -- from country to country and city to city.

Rapid Testing Needed - Desperately

Mental Time Machine - to March 2020.

- Hospitals are being overrun and people are dying.
- Slow Tests

HEALTH INC.

Why It Takes So Long To Get Most COVID-19 Test Results

March 28, 2020 · 12:54 PM ET

JULIE APPLEBY

FROM **KHN**



Rapid Testing Needed - Desperately

Mental Time Machine - to March 2020.

- Hospitals are being overrun and people are dying.
- Slow Tests
- Rapid test “issues”

ABC NEWS CORONAVIRUS HEALTH & SCIENCE

Promising new 15-minute test for coronavirus comes with caveats

With a sensitivity of 60%, the test could miss 4 out of 10 every cases.

By Dr. Angela N. Baldwin

March 26, 2020, 6:29 PM • 8 min read



SRC: ABC News

Rapid Testing Needed - Desperately

Mental Time Machine - to March 2020.

- Hospitals are being overrun and people are dying.
- Slow Tests
- Rapid test “issues”
- No answer was ‘out of bounds’



Doctors in Italy, Spain using ultrasound for COVID-19

By Theresa Pablos, AuntMinnie.com staff writer

March 23, 2020 -- As Europe struggles to cope with the novel coronavirus outbreak, one doctor in Spain is using point-of-care ultrasound (POCUS) to track his own COVID-19 disease. His findings echo those of other doctors on the front lines in showing that ultrasound can help with diagnosis, treatment, and admission decisions.

Dr. Yale Tung-Chen, PhD, an emergency medicine physician at an academic hospital in Madrid, was diagnosed with COVID-19 following a rapid polymerase chain reaction (PCR) test on March 8. Like his patients, many of his first symptoms were mild -- a little worse than a common cold, he said during a March 19 webinar on POCUS for COVID-19.



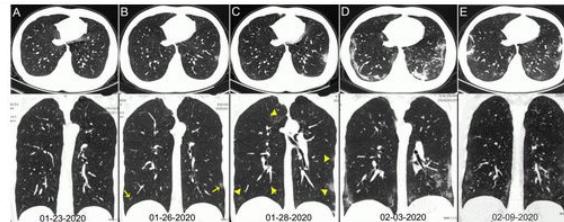
CT Scans for "Rapid" Testing

CT Scans were known to be gold standard early

NEWS | COMPUTED TOMOGRAPHY (CT) | FEBRUARY 26, 2020 | MELINDA TASCHETTA-MILLANE AND DAVE FORNELL

CT Provides Best Diagnosis for Novel Coronavirus (COVID-19)

CT scans can detect coronavirus in patients before RT-PCR lab testing



Chest CT images of a 29-year-old man with fever for 6 days. RT-PCR assay for the SARS-CoV-2 using a swab sample was performed on Feb. 5, 2020, with a positive result. (A column) Normal chest CT with axial and coronal planes was obtained at the onset. (B column) Chest CT with axial and coronal planes shows minimal ground-glass opacities in the bilateral lower lung lobes (yellow arrows). (C column) Chest CT with axial and coronal planes shows increased ground-glass opacities (yellow arrowheads). (D

CT Scans for Rapid Testing

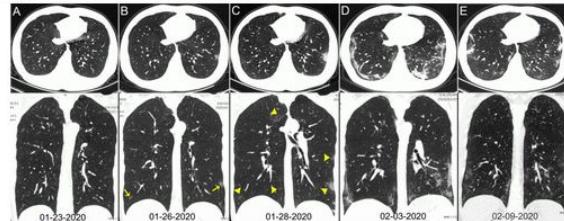
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Issues

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CT Scans for Rapid Testing

CT Scans were known to be gold standard early

Issues: Radiation

Exposure measured in mSv



SOURCE: WNA, RADIOLGYINFO.ORG, REUTERS

Low Dose CT Scans

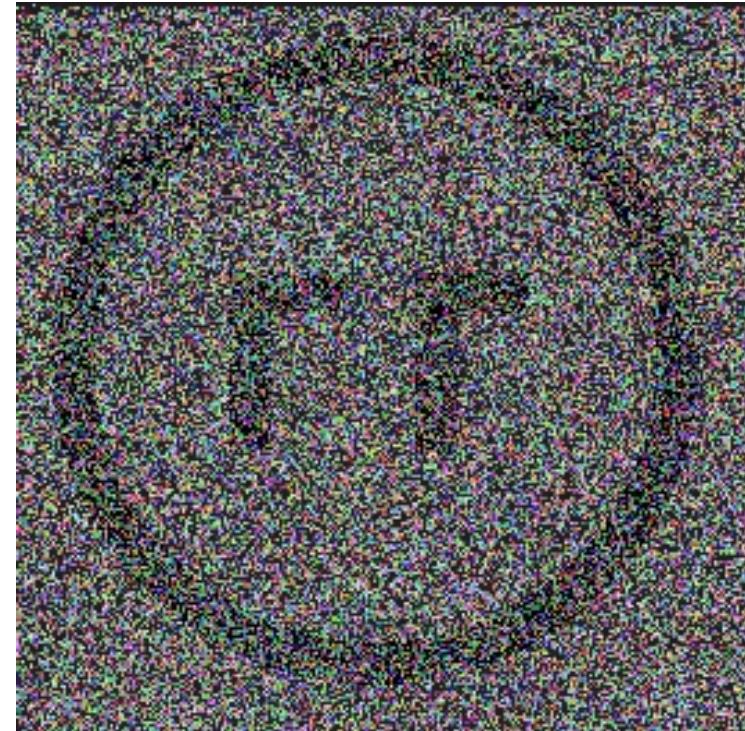
First usage: Late 90s

Lower Radiation:

~ 1.4 mSv

(compared with 6-8 for normal CT scans)

Can be noisy

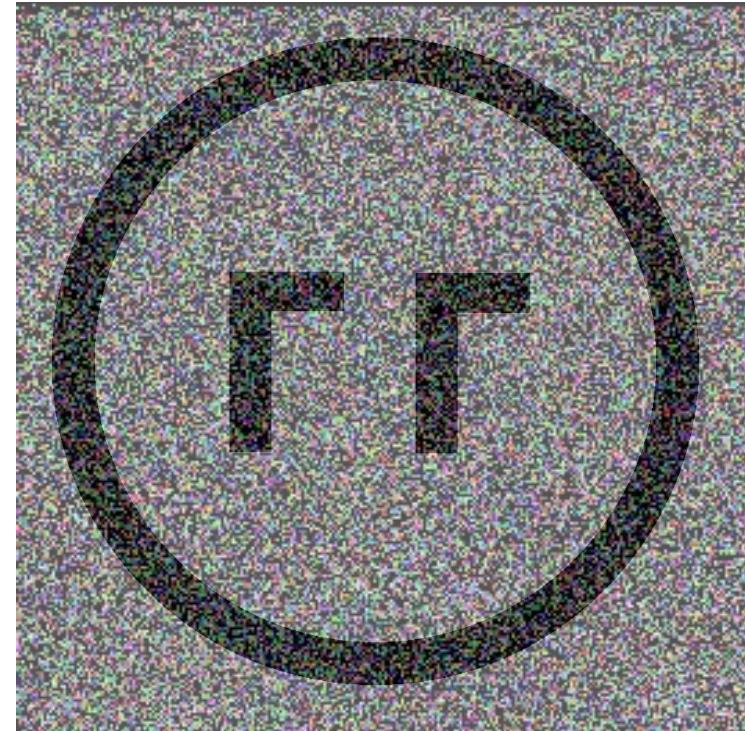


“De-Noising” Images

Papers about from 00s

Most use some flavor of SVD (or a hack to do SVD on computers of the size available in the 00s)

To do an ‘honest’ SVD required ~500GB RAM



<Land the plane>

In March of 2020 there was high need for rapidly deployable, rapid testing for COVID.

CT Scans were known to be a good tool, and widely available but carried radiation dosage risks.

Low-dose CT scans mitigate dosage risk but produce noisier images.

We present a method for denoising images based on open source, cloud native software that any site could very quickly deploy.



Intermission

Act 3: Dramatic Conclusion

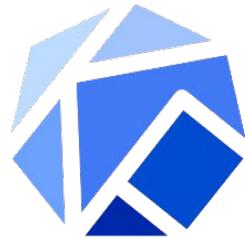
Another recap

In March of 2020 there was high need for rapidly deployable, rapid testing for COVID.

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Kubeflow



MAHOUT

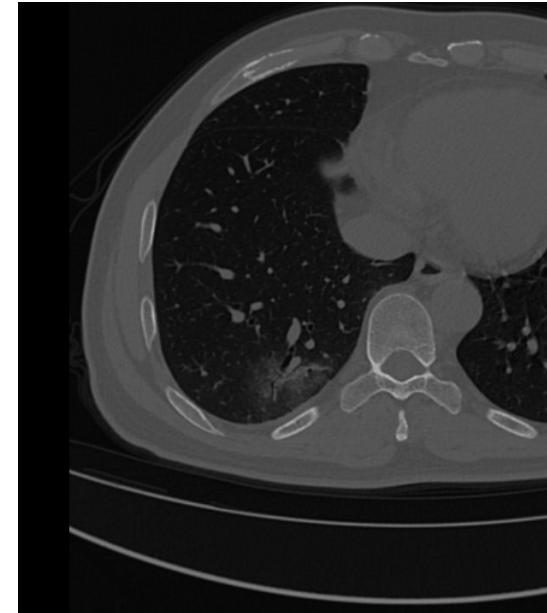
Data Source

"Thanks to technology, we were able to spread knowledge faster than coronavirus was spreading itself. In a few days we've registered access from thousands of cities, most of them at that moment without COVID-19. That allowed radiologists, that play an important role in the diagnosis, to have a first hands-on experience in a disease that would later change the world."



Omir Antunes Paiva
RAIOSS

<https://www.coronacases.org>



SRC: <https://coronacases.org>

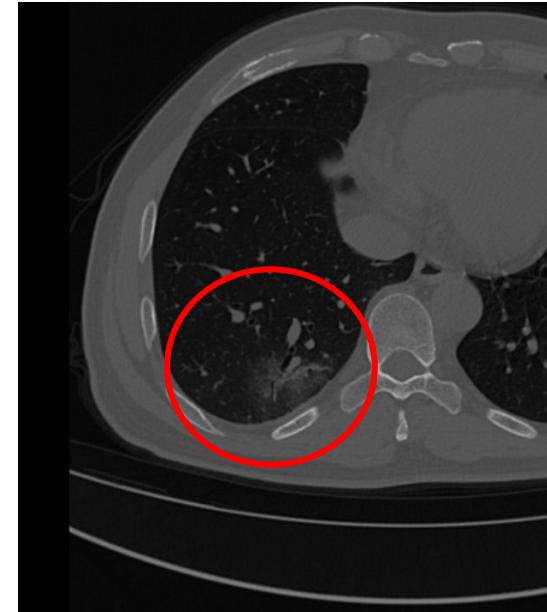
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Omir Antunes Paiva
RAIOSS

<https://www.coronacases.org>



SRC: <https://coronacases.org>

Why (F)OSS Based Solution



WORLD

How Covid-19 Has Widened the Gap Between Rich and Poor Countries

Progress in bridging the economic divide between developed and developing nations has been set back by the Covid-19 pandemic

By [Jason Douglas](#) and [Andrew Barnett](#)
Jan. 14, 2022 5:30 am ET

SHARE A TEXT 82 RESPONSES

The [Covid-19 pandemic](#) is widening the gap between rich and poor countries, a trend that threatens to reverse years of economic progress and set back efforts to alleviate global poverty.

The pandemic pushed the global economy into recession in 2020, but richer nations have bounced back faster than poorer ones, [thanks to widespread access to vaccines](#) and lavish programs to support businesses and workers through lockdown.

The U.S. economy regained its pre-pandemic size [in the second quarter](#) of 2021, and most other big economies are expected to follow suit in 2022, if they haven't already.

The economies of many developing nations, however, [could take years to regain their 2019 size](#). The International Monetary Fund has labeled the widening rift "the great divergence."

- Always Open Source
- FOSS: The Great Equalizer
- FOSS: Moves as the speed of free and open source software
- /soapbox

Src: The Wall Street Journal

The Pipeline: Overview

S3 buckets of images (can be easily swapped out to other image repo)

- > PyDiCOM to turn CT scan into numerical matrix, write matrix to disk
- > Load matrix in apache spark (~500 MB each) then wrap RDD into Mahout DRM
- > DS-SVD on Mahout DRM (why couldn't do this in NumPy?)
- > DS-SVD results in two matrices- one of basis vectors, one of weights per image- to “de noise” you only use first X% of basis vectors. These get output and can be easily rastered using a laptop.

S3 Buckets



Easiest and most portable solution.

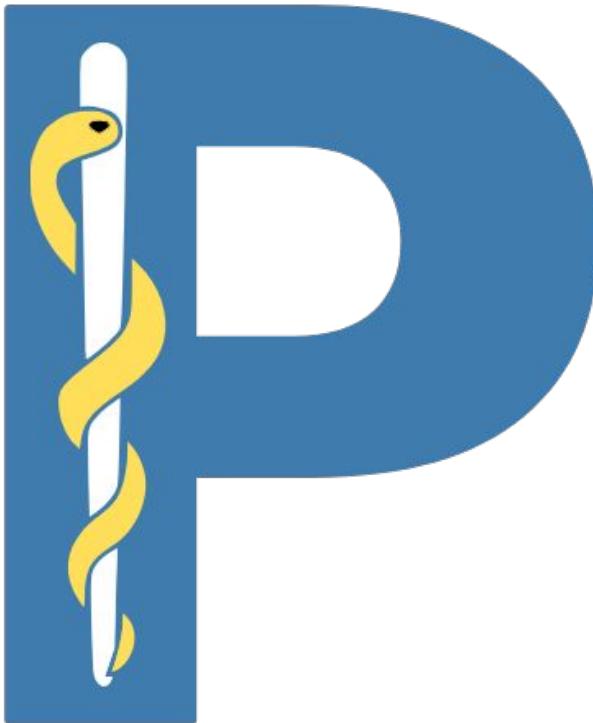
Every major cloud has some compatibility layer with S3 buckets.

Usually not the most performant.

Other issues too.

But, they are the most widely supported!

Loading data: PyDICOM



To process into numerical matrices

Then dump to PVC

(note: this has implications for parallelism)

Pipeline: Read from Disk to RDD to DRM

Requires a ResourceOp

Which requires a manifest



Pipeline: Read from Disk to RDD to DRM



Pipeline: DS-SVD

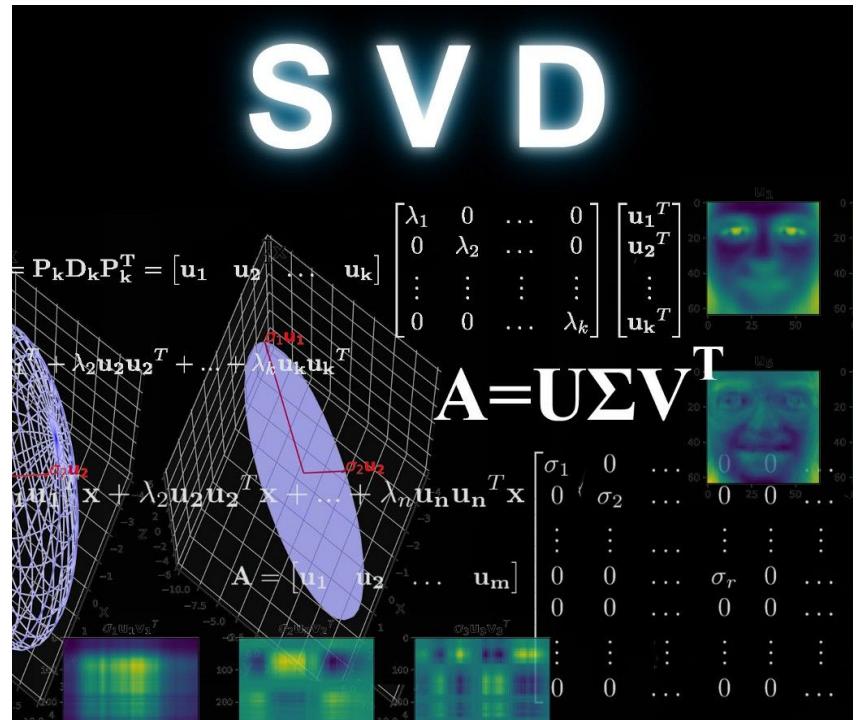
What is DS-SVD

Why do you need Mahout?

- Why not Spark?
- Why not NumPy?

Output: DS-SVD results in two matrices- one of basis vectors, one of weights per image- to “de noise” you only use first X% of basis vectors.

These get output and can be easily rastered using a laptop



SRC: Towards Data Science

<https://towardsdatascience.com/understanding-singular-value-decomposition-and-its-application-in-data-science-388a54be95d>

Visualizing Results

Not sure if original (a) was a
Low dose

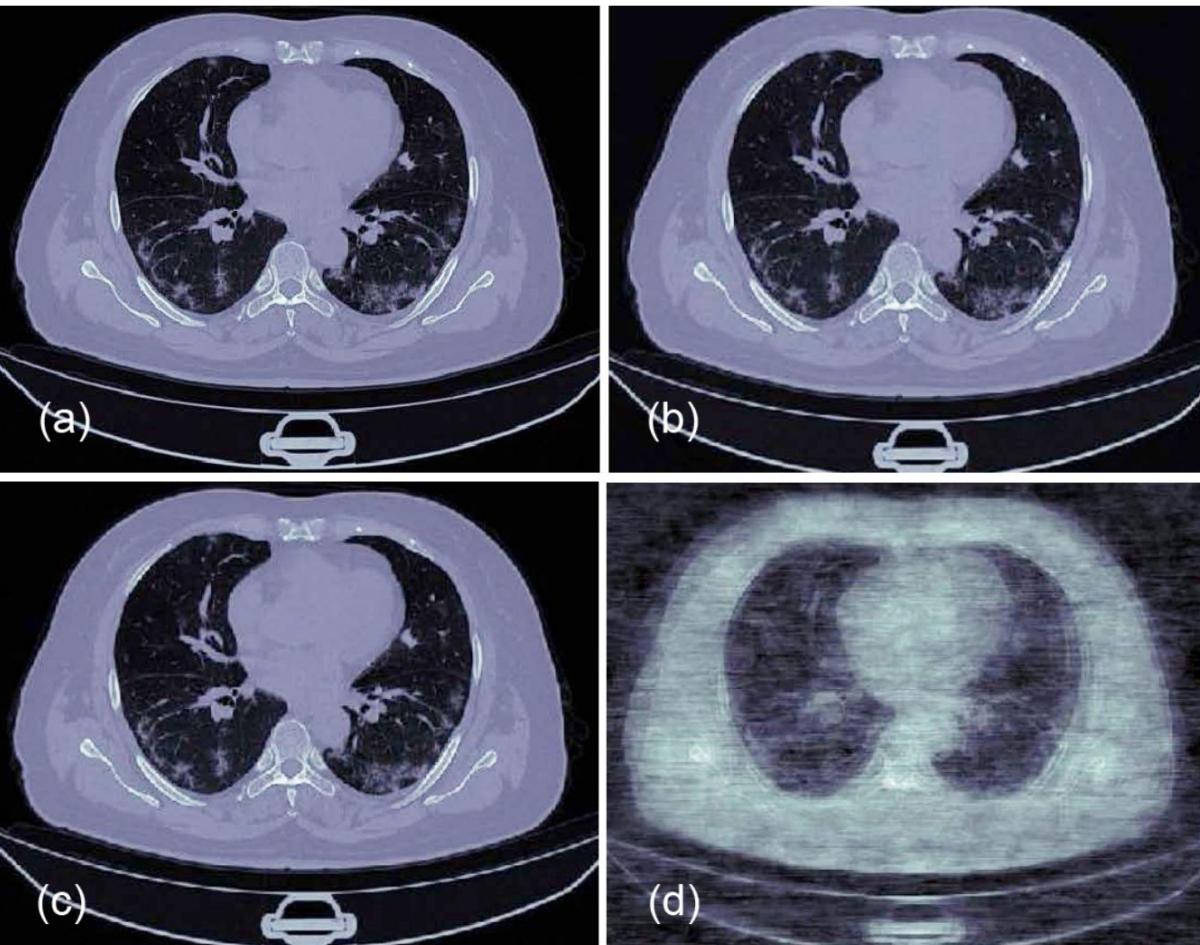


Figure 1 The lungs of a COVID-19 positive patient. Images of “best” resulting basis vectors: (a) Original, (b) Composite image: $k=50$, oversample=15, power_iters=2, (c) Composite image: $k=244$, oversample=15, power_iters=2, (d) Composite image: $k=300$, oversample=15, power_iters=2.

Epilogue

Epilogue

What Came from the Adventure

Before we were published the world changed

Before we published- the world changed. Tests got cheap and more widely available.

Positive Outcomes: Science

A real world application of some tech that was hypothesized about in late '00s early '10s (published paper plug, advancing scientific knowledge, importance of reproducible code, pimp git repo, not just code, full pipeline).

Spark + Kubernetes Improvements

We didn't have a shuffle service on Kube

- Worked on alternative (w/ decommissioning) @ Apple
- Were working on upstreaming one now Netflix

Looked to alternative solutions

- Object store as an alternative (in fallback mode)

Pod allocation scale up/down is kind of flaky

- Excited to see progress in Volcano & Yunikorn + Spark integration (yay)

Resource Profiles

- Training & ETL stages can use different types of resources (not just quantity)

Positive Outcomes: Spark + Kubeflow Example

(for truly distributed use case)(because spark can ‘trick’ you with things that work in local mode, but don’t scale to distributed.

<https://github.com/rawkintrevo/basis-vectors-for-covid-kf>

Positive Outcomes: Cool Example for Book

Buy our books, they make a great gift for whatever holiday is next.

Article:

<https://nobleresearch.org/Doi/10.14312/2399-8172.2020-6>

O'REILLY®

Kubeflow for Machine Learning

From Lab to Production



Trevor Grant, Holden Karau, Boris Lublinsky,
Richard Liu & Ilan Filonenko
Foreword by Chris Albon

Epilogue

Maybe less writing to Disk?



Kubeflow makes using different tools possible

- Non-distributed tools are not distributed* (e.g. PyDicom)
- Writing to disk / s3 between each tool
 - e.g. changing tools is possible but still slow

How can we make multiple tools less painful?



- Avoid writing to disk (and remote disk)
 - Kubeflow pipelines do allow us to return arbitrary items so technically possible
- Move layer of parallelization up the stack
- Probably more things but... I'm lazy

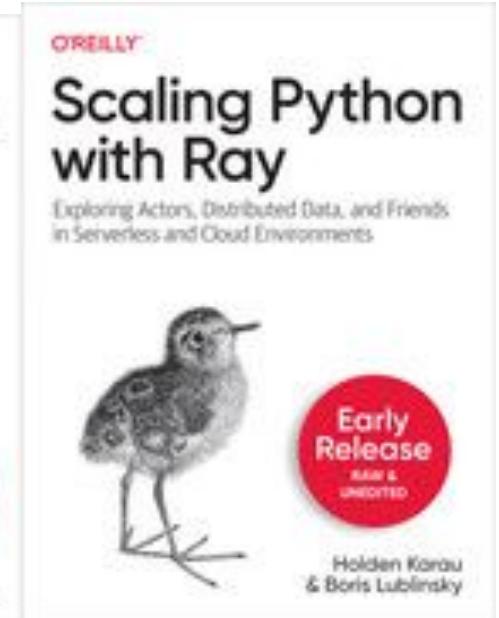
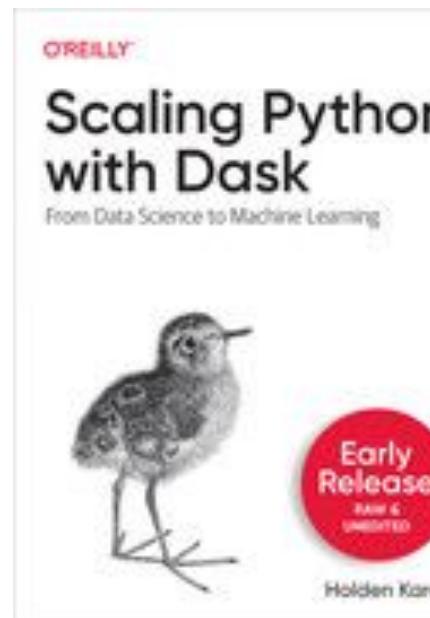
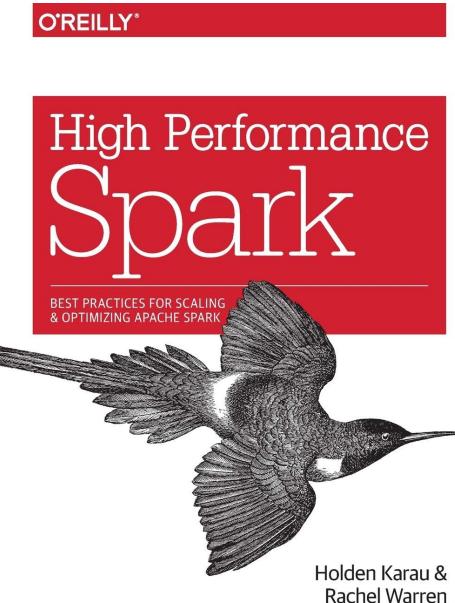
I have three standards, let's make a 4th*

-

Or another book :p



- Ray Distributed: Make using multiple tools less expensive
- Dask: Be a more complete data science tool, so we use less tools
- Either way buy* some new books



Do we still need Kubeflow?



- TL;dr - yes
- Ray/Dask library isolation doesn't extend beyond virtualenvs
- Serving

Also kids books. No they don't fix anything.



Available now ^
Kube + flo's place

Distributed Computing 4 Kids
to be available "soon">>



The End (?)

Q&A

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OR

trevor.d.grant@gmail.com