

Week 7: Ethics in Algorithms

Charlotte Hadley

Ethics in algorithms... what does it mean?

Ethics in algorithms... what does it mean?

“Ethics in algorithms” paints a picture that we only need to consider ethics when writing algorithms.

Data ethics is a **might** be a better term for what we’re discussing.

Data ethics includes, but isn’t limited to:

- How data is collected
- How data is processed (by algorithms)
- How data is consumed to build products and services

- How data is released

Is it ethical for data about us to be collected without our knowledge?

Companies are hiring data ethicists in droves.

Data ethics... you mean machine learning, big data and AI!

Machine learning, big data and AI are all tremendously exciting and definitely always require *some* data.¹

But data ethics is important every time we're dealing with sensitive and/or private data.

Even if we've got survey data about attitudes to green spaces during the pandemic.

In this course when we talk about data ethics we're also talking about the ethics of algorithms.

Ethics & Moral Philosophy

Ethics & Moral Philosophy

Moral philosophy and the history of ethics is fascinating.

We're just going to completely ignore it.

Right to privacy

Right to privacy

The Universal Declaration of Human Rights² provides universal right to privacy.

Article 12

No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks.

We're going to extend this to include right to privacy in data collection and sharing of data.

But let's look at algorithms a little bit more first.

Self-driving cars

Self-driving cars (I)

There's a continuum of “self-driving car” technology. For discussion purposes, let's define the tech as follows:

- Who is responsible for a road traffic collision?
- How does the automated driving system respond to trolley problem situations?
 - Does the car prioritise reducing risk to the driver or a pedestrian
 - Does the car prioritise reducing risk to other vehicles or pedestrians?

A car on public roads under the control of an automated driving system that controls acceleration, breaking and driving direction. The driver does not have active control of the car, but can disengage the automated driving system and resume control.

What ethical questions does the addition of self-driving cars to **existing** road networks raise?

Self-driving cars (II)

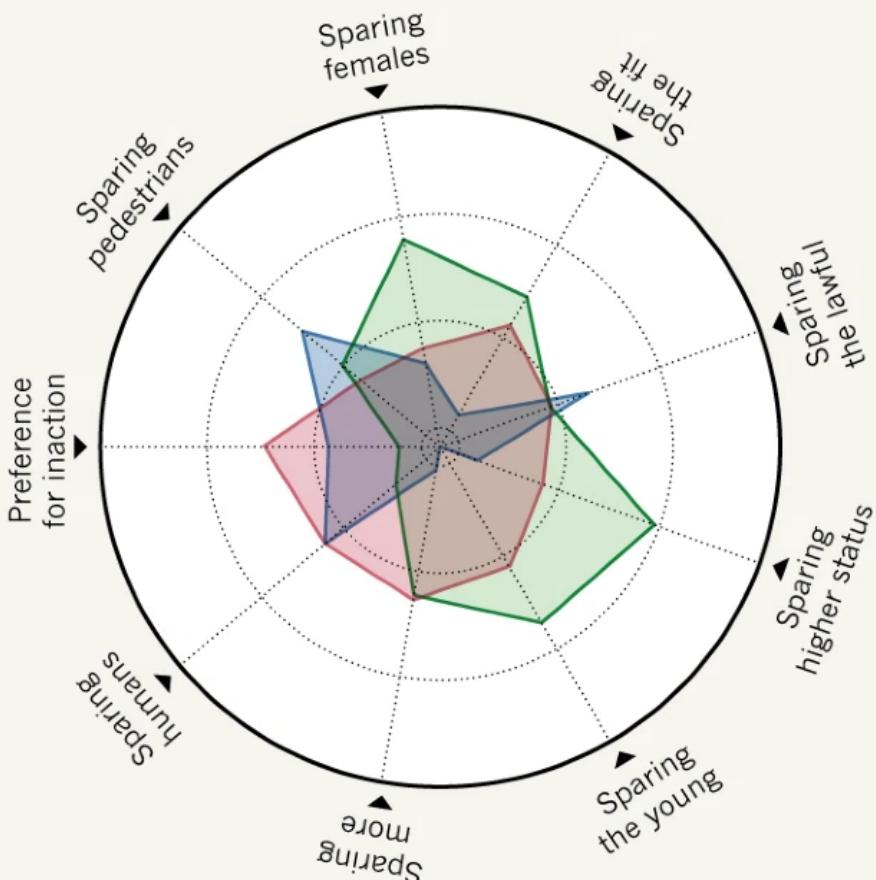
Awad et al³ surveyed 2.3million people in 2018 to explore attitudes to moral dilemmas faced by autonomous vehicles.

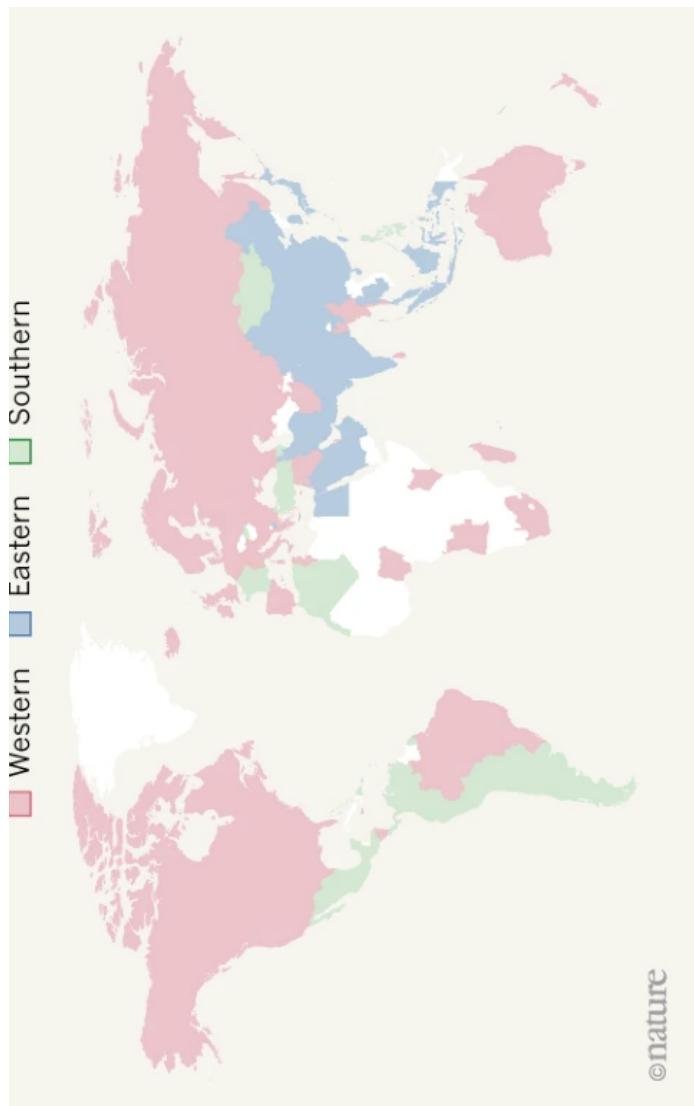
Attitudes vary by geographic region of participants and the demographics of potential *accident* victims.

Should the ethical decision making of autonomous vehicles vary dependent on location?

MORAL COMPASS

A survey of 2.3 million people worldwide reveals variations in the moral principles that guide drivers' decisions. Respondents were presented with 13 scenarios, in which a collision that killed some combination of passengers and pedestrians was unavoidable, and asked to decide who they would spare. Scientists used these data to group countries and territories into three groups based on their moral attitudes.





This data visualisation is derived from Awad et al³ but appears in Maxmen 2018⁴

Self-driving cars (|||)

Reliable and unbiased estimations of autonomous vehicle safety are difficult to find - and interpret.

This statistic is repeated **everywhere** even in 2022

As more autonomous vehicles are used by untrained drivers in real-world circumstances we'll collect more information about their safety.

But it's important we try and understand *how* autonomous vehicles make their decisions.

Self-driving cars also have an accident rate of 9.1 crashes per million miles driven – which is more than double that of regular vehicles.

It's derived from a 2015 report⁵... and a total of 11 collisions.

Self-driving cars (IV)

Self-driving vehicles use many different tools for sensing and measuring their environment.

- Computer vision uses “regular cameras” and categorises what it sees.



There's considerable debate [and patent dispute] about two competing technologies: LiDAR and Computer Vision.

- LiDAR continuously pulses UV light, measures reflection times and builds a 3D visual map. This data is then clustered and classified to identify things around the car.

Self-driving cars (IV)

As we question the ethical considerations of autonomous vehicles it's crucial to understand **how** vehicles make decisions - particularly during accidents.

Does the vehicle make Fair, Accountable and Transparent (FAT) decisions?

Thankfully, both LiDAR and computer vision provide surprisingly high **transparency**.

This table comes from a fatal collision report⁶ between an autonomous vehicle and a pedestrian.

Time to Impact (seconds)	Speed (mph)	Classification and Path Prediction ^a	Vehicle and System Actions ^b
-9.9	35.1	--	Vehicle begins to accelerate from 35 mph in response to increased speed limit.
-5.8	44.1	--	Vehicle reaches 44 mph.
-5.6	44.3	<u>Classification:</u> <i>Vehicle</i> —by radar <u>Path prediction:</u> <i>None</i> ; not on path of SUV	Radar makes first detection of pedestrian (classified as vehicle) and estimates speed.
-5.2	44.6	<u>Classification:</u> <i>Other</i> —by lidar <u>Path prediction:</u> <i>Static</i> ; not on path of SUV	Lidar detects unknown object. Object is considered new, tracking history is unavailable, and velocity cannot be determined. ADS predicts object's path as static.
-4.2	44.8	<u>Classification:</u> <i>Vehicle</i> —by lidar <u>Path prediction:</u> <i>Static</i> ; not on path of SUV	Lidar classifies detected object as <i>vehicle</i> ; this is a changed classification of object and without a tracking history. ADS predicts object's path as static.
-3.9c	44.8	<u>Classification:</u> <i>Vehicle</i> —by lidar <u>Path prediction:</u> Left through lane (next to SUV); not on path of SUV	Lidar retains classification <i>vehicle</i> . Based on tracking history and assigned goal, ADS predicts object's path as traveling in left through lane.
-3.8 to -2.7	44.7	<u>Classification:</u> alternates between <i>Vehicle</i> and <i>other</i> —by lidar <u>Path prediction:</u> alternates between <i>static</i> and left through lane; neither considered on path of SUV	Object's classification alternates several times between <i>vehicle</i> and <i>other</i> . At each change, tracking history is unavailable; ADS predicts object's path as static. When detected object's classification remains same, ADS predicts path as traveling in left through lane.
-2.6	44.6	<u>Classification:</u> <i>Bicycle</i> —by lidar <u>Path prediction:</u> <i>Static</i> ; not on path of SUV	Lidar classifies detected object as <i>bicycle</i> ; this is a changed classification of object and object is without a tracking history. ADS predicts bicycle's path as static.
-2.5	44.6	<u>Classification:</u> <i>Bicycle</i> —by lidar <u>Path prediction:</u> Left through lane (next to SUV); not on path of SUV	Lidar retains <i>bicycle</i> classification; based on tracking history and assigned goal, ADS predicts bicycle's path as travelling in left through lane.

We can see the autonomous vehicle repeatedly, and inconsistently misidentified a pedestrian.

Fairness, Accountability and Transparency

Fairness, Accountability and Transparency

Fairness

Fairness: 5 (or 6) Sources of Bias

Frustratingly, I can't find the source for this! But this list has been around since at least 2014⁸.

- Proxies
- Limited features
- Skewed sample
- Tainted examples
- Sample size disparities

Broadly in the literature (and in essays on the subject) there are 5 common sources of bias in training datasets.

These biases result in unfair treatment of individuals/groups by an algorithm. Examples of unfair treatment include

- Refusal of service
- More expensive services
- Reduced range of services

When these services include healthcare the ramifications can be life threatening.

The assessment limits itself to these 5 sources.
It's worthwhile mentioning that sometimes these bias is knowingly, and deliberately left (or added) to a training dataset.
This is called **masking**⁸.

Fairness: Proxies

Proxies are the easiest to identify and describe of these sources of bias.

When training our algorithms we want to remove potentially biasing attributes like race, gender, age or religious belief - because we don't want an algorithm to discriminate, disadvantage or advantage a specific group.

However, there are **many** other variables in a dataset that are **proxies** for these attributes. Can you think of any?

- Systemic racism means that income, neighborhood and similar variables are strong proxies for race.

“Redlining is the practice of arbitrarily denying or limiting financial services to specific neighborhoods, generally because its residents are people of color or are poor.”

- Facebook friendships can be a strong proxy for sexual orientation¹¹

Fairness: Limited Features

This is a harder bias to describe (and to verify). It's also **extremely frustrating to pin down examples.**

Limited features is a consequence of having smaller datasets for minority groups, or specific combinations of sensitive attributes.

Individuals in these groups will be subject to less accurate classifications (or predictions) than other groups.

This article gives a theoretical example: <https://towardsdatascience.com/sources-of-unintended-bias-in-training-data-be5b7f3347d0>

Limited features is a pre-requisite for skewed samples, our next topic.

Fairness: Skewed sample (I)

| It's kind of unfair this is collected together with proxies, limited features, tainted examples, sample size disparities

Skewed samples is a bias in your algorithm when existing skewness due to limited features results in an algorithm that **becomes more skewed over time** - creating a biased feedback loop¹². Please do read the Ensign et al's¹² paper from 2017 as it explains this really well.

Given historical crime incident data for a collection of regions, decide how to allocate patrol officers to areas to detect crime
...
Since such discovered incidents only occur in neighborhoods that police have been sent to by the predictive policing algorithm itself, there is the potential for this sampling bias to be compounded, causing a runaway feedback loop.

Fairness: Skewed sample Google Flu (I)

Another really great example with an easy to follow about the skewed samples behind issues with Google Flu's predictive power, Lazer et al 2014¹³

In 2009 Google published details about their Google Flu Trends (GFT) prediction engine¹⁴ that used search results to predict flu outbreaks.

The theory being that ill people search for symptoms before they would be otherwise detected.

However, the whole thing is somewhat questionable as

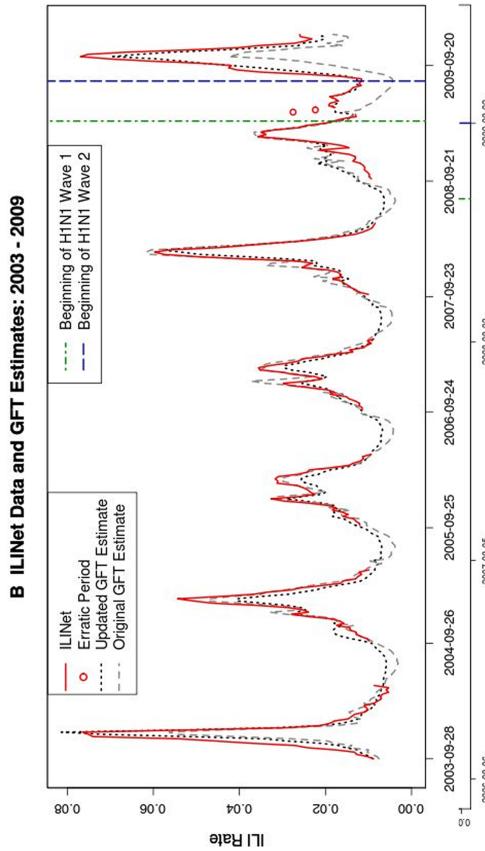
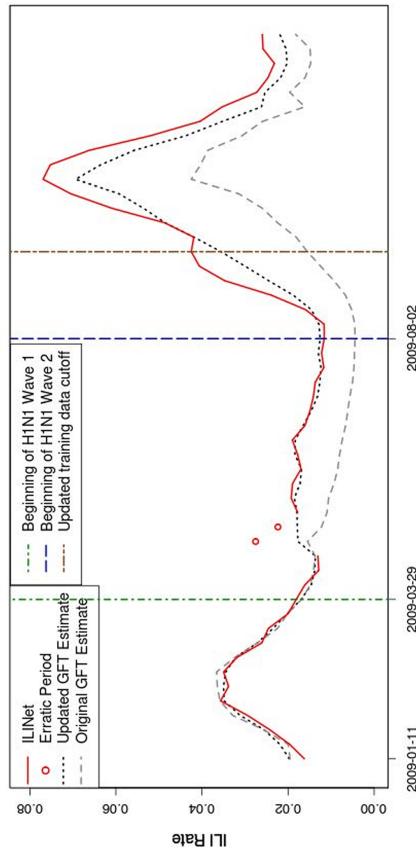
GFT has never documented the 45 search terms used, and the examples that have been released appear misleading¹⁵

Source: Lazer et al 2014¹³

Fairness: Skewed sample Google Flu (III)

Coincidentally, the first big failure of the service was the 2009 A–H1N1 outbreak¹⁵.

The GFT didn't detect the non-seasonal wave of H1N1 during the summer of 2009.



Google quickly updated the GFT algorithm later in 2009 and the improved algorithm did a better job of predicting the outbreak.

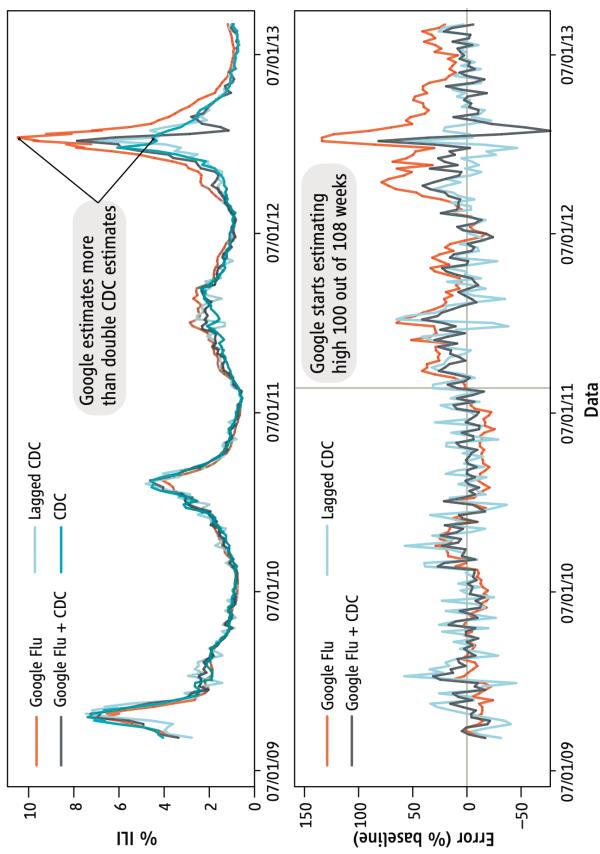
Fairness: Skewed sample Google Flu (III)

However, from 2011 onwards the GFT consistently overestimated flu outbreaks¹³ and became increasingly unreliable.

Lazer et al¹³ posit two reasons for this:

- Big data hubris

Was the algorithm a glorified winter detector?



Source: Lazer et al¹³

- Algorithm dynamic

Google has many competing algorithms at play. The service has a recommendation engine that shows potentially interesting (or useful?) search terms. Developments in the

Fairness: Tainted examples (I)

We need to talk about supervised learning.

That's all well and good if we're doing something like classifying the **titanic survival dataset**.

Do you know the difference between supervised and unsupervised learning?

... but often our categories aren't absolute, eg

- Google user has the flu!
- Rating a driver's likelihood of an accident
- Rating a "good job candidate"

In supervised learning we create categories and assign training data to these categories.

The algorithm will classify all future inputs as belonging to one of these categories.

Let's look into the job candidate example more

Fairness: Tainted examples in Recruitment (I)

Algorithms are used ubiquitously and sometimes aggressively in HR and recruitment. Frajai and László published a literature review on the topic in 2021¹⁶.

This is an example of potential tainted example bias because there isn't a universal truth to who is a good job candidate.

These algorithms are often baked into software to automatically filter through CVs.

There are at least two different methods for categorising “good” candidates:

- Who gets hired. And we know there are “shocking levels of discrimination in hiring”¹⁷
- Work evaluation scores of recruited people. There’s strong evidence of discrimination in these scores¹⁸.

The algorithms are celebrated for being fast, efficient and allowing recruiters to focus on more interesting and human required tasks.

This couldn’t possibly create issues

Fairness: Sample Size Disparity (I)

Unfortunately, even perfectly balanced [untainted and unskewed] training data with untainted categories can have bias. Sample size disparity is a common example of this.

Sample size disparity exists when completely balanced datasets have disparity in the size of subgroups.

The most widely cited (and easy to follow) example of this is the Nymwars of 2011 - <https://en.wikipedia.org/wiki/Nymwars>.

This disparity results in unfair behaviour of the algorithm when applied to real-world datasets.

Fairness: Sample Size Disparity (II)

In 2011 Google implemented a real name policy for Google+.

There are significant privacy issues with this policy.

But users also found their names rejected as “not real”.

Folks with names outside of the first and last name pattern - eg Charlie Hadley - found their names rejected.

This is widely blamed on the training datasets having sample size disparity - there were fewer instances of other name forms.

I recommend reading this article
Falsehoods Programmers Believe About Names – With Examples¹⁹.

... some more case studies

“Man is to computer programmer as woman is to homemaker” (1)

In 2016 Bolukbasi et al²⁰ demonstrated how the extremely common **word2vec** algorithm shows significant gender-bias.

For example, if you enter ‘france’, distance will display the most similar words and their distances to ‘france’, which should look like:

word	cosine.distance
spain	0.678515
belgium	0.665923
netherlands	0.652428
italy	0.633130
switzerland	0.622323
luxembourg	0.610033
portugal	0.577154
russia	0.571507
germany	0.563291
catalonia	0.5334176

word2vec is a patented algorithm²¹ that - when trained on a given text corpus - will find similar/synonymous words for a given input.

Google provides a useful introduction to how the system works.

“Man is to computer programmer as woman is to homemaker”
(III)

“Man is to computer programmer as woman is to homemaker” (III)

What sources of bias are included in this example?

- Proxies
- Limited features
- Skewed sample
- Tainted examples
- Sample size disparities

Racial bias in photography (I)

Smartphone manufacturers have recently started advertising how their devices **accurately photograph the beauty of all skin tones**²².

This has been a **known issue in photography for decades**, in many different situations.

In pre-digital photography days, Kodak issued “Shirley cards” for colour-balancing images. These cards exclusively contained Caucasian models until the 1990s.

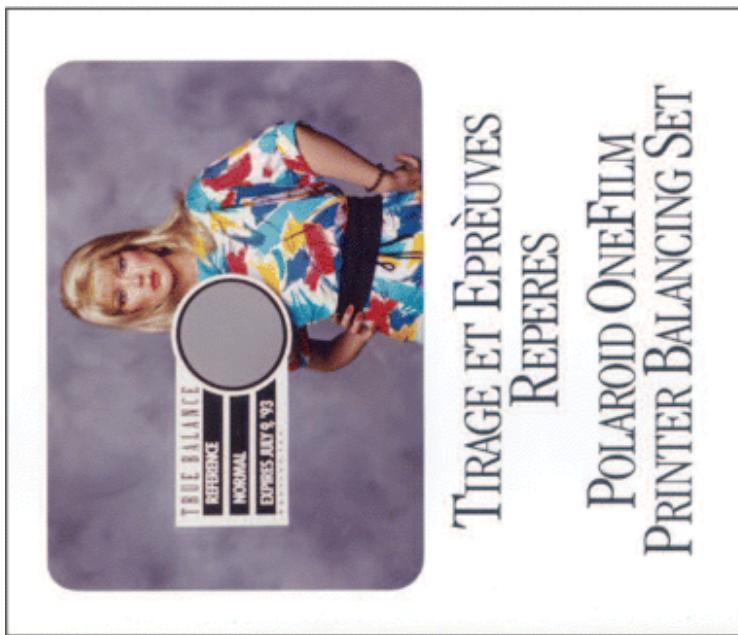


Figure 1
Polaroid Shirley card (Printed with permission of Polaroid)

Source: Lorna Roth 2009²³

Racial bias in photography (II)

This issue has also been pervasive in digital photography.

The continued use of the Fitzpatrick skin tone scale is largely to blame.

TABLE 1 Fitzpatrick Classification of Skin Types I through VI

Type I	Type II	Type III	Type IV	Type V	Type VI
White skin. Always burns, never tans.	Fair skin. Always burns, tans with difficulty.	Average skin color. Sometimes mild burn, tan about average.	Light-brown skin. Rarely burns. Tans easily.	Brown skin. Never burns. Tans very easily.	Black skin. Heavily pigmented. Never burns, tans very easily.

Source: Ward et al²⁵

Dr. Ellis Monk's research²⁴ has culminated in the Monk Skin Tone Scale with evidence improvements in processing of images compared to the Fitzpatrick scale.

Racial bias in photography (III)

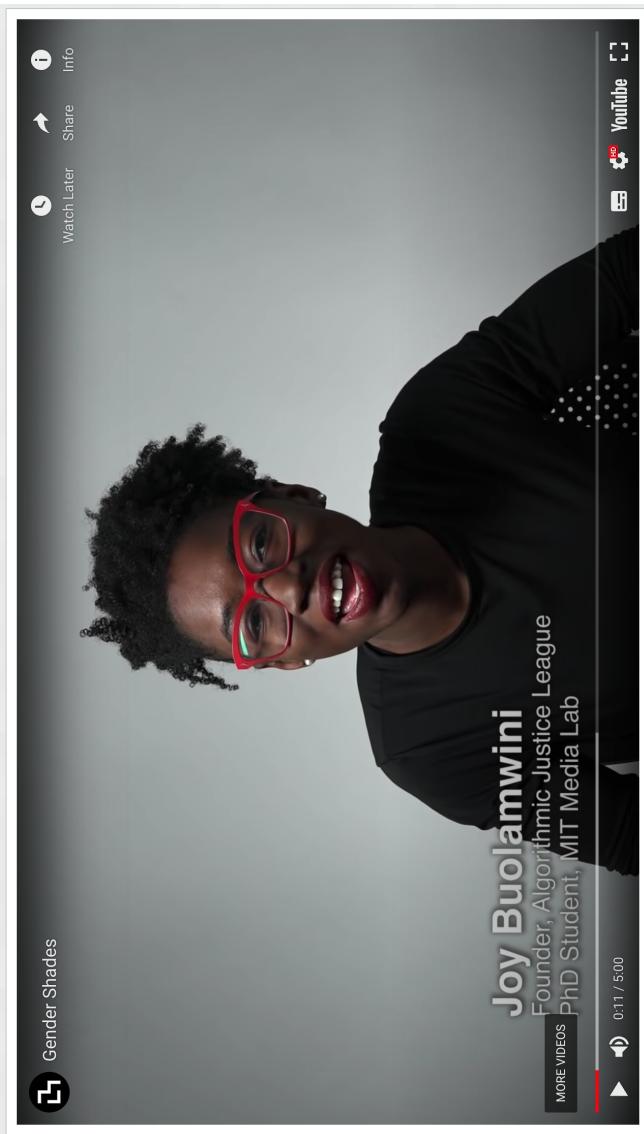
I'd like to recommend some additional resources to learn about this:

- Vox Media's video essay [Color film was built for white people. Here's what it did to dark skin.](#)²⁶.
- [The Racial Bias Built Into Photography by the NY Times](#)²⁷
- Lorna Roth's research paper [Looking at Shirley, the Ultimate Norm: Colour Balance, Image Technologies, and Cognitive Equity](#)²⁸
- Google's [Skin Tone Research](#) with Dr. Ellis Monk.

Racial bias in face analysis ()

This is a fundamental problem in all face analysis and face detection software.

Joy Buolamwini does a much better job of explaining this in 5 minutes than I can.



Source: [gendershades.org²⁸](http://gendershades.org)

Racial bias in face analysis & photography

What sources of bias are included in this example?

- Proxies
- Limited features
- Skewed sample
- Tainted examples
- Sample size disparities

Accountability & Transparency

Accountability & Transparency

These two terms are used interchangeably and confusingly. That's okay. In the assessment discuss how these two concepts relate to one another and you'll be fine.

There's a really useful definition given by the EU “*governance framework for algorithmic accountability and transparency*”²⁹

The primary role of transparency is identified as a tool to enable accountability. If it is not known what an organisation is doing, it cannot be held accountable and cannot be regulated.

...

An important difference between transparency and accountability is that accountability is primarily a legal and ethical obligation on an individual or organisation to account for its activities, accept responsibility for them, and to disclose the results in a transparent manner.

... but the rest of the document is very heavy reading.

Accountability

For a more thorough exploration of accountability I recommend reading Caplan et al³⁰.

Transparency and gaming the system

It's worthwhile mentioning that transparency can result in “gaming the system” in which an algorithm is applied:

Also, in some cases, transparency may lead to groups and individuals “gaming the system.” For example, even the minimal openness surrounding how the trending feature on Twitter surfaces topics has allowed it to be manipulated into covering certain topics by bots and coordinated groups of individuals. Therefore, different contexts may call for different levels of transparency.

Source: Caplan et al 2018³⁰

- How else could we game algorithms?

Other sources of unfairness

Other sources of unfairness

Earlier we tried to categorise sources of bias:

- Proxies
- Limited features
- Skewed sample
- Tainted examples

-Sample size disparities

These are almost always concerned with the training data behind algorithms.

Let's look at some of these!

There's a whole universe of ways we can bias an algorithm by *how it's applied*.

Fairness and Abstraction in Sociotechnical Systems

Selbst et al published an excellent paper in 2019³¹ on “abstraction traps”.

I think they’re really useful and give us further context for our discussion of fairness.

These traps are designed to help us account for the interactions between the technical systems behind our algorithms and the social world in which they’re applied.

The next several slides explores these traps.

Selbst Abstraction: The Framing Trap

Failure to model the entire system over which a social criterion, such as fairness, will be enforced

Example:

In the US criminal justice pipeline algorithmically trained risk assessment tools are used to predict the “risk” of a defendant and determine if parole is awarded.

However - usually this is the risk the defendant fails to appear at court hearings.
Reoffending is only occasionally considered in these models.

These risk assessment tools are presented only as recommendations to judges. They do not account for consistently (see³¹) different consideration between judges.

The intended application of the algorithmically trained risk assessment does **not take** into account their use by judges and therefore the apparent fairness cannot be measured

Selbst Abstraction: The Portability Trap

Failure to understand how repurposing algorithmic solutions designed for one social context may be misleading, inaccurate, or otherwise do harm when applied to a different context

Here's a really nice quote

Within computer science, it is considered good practice to design a system that can be used for different tasks in different contexts. “But what that does is ignore a lot of social context,” says Selbst. “You can’t have a system designed in Utah and then applied in Kentucky directly because different communities have different versions of fairness. Or you can’t have a system that you apply for ‘fair’ criminal justice results then applied to employment. How we think about fairness in those contexts is just totally different.”

Source: Karen Hao³²

Selbst Abstraction: The Formalism Trap

Failure to account for the full meaning of social concepts such as fairness, which can be procedural, contextual, and contestable, and cannot be resolved through mathematical formalisms

I did promise we would ignore moral philosophy, but it's important for a moment.

Fairness and discrimination are complex concepts that philosophers, sociologists, and lawyers have long debated. They are at times procedural, contextual, and politically contestable, and each of those properties is a core part of the concepts themselves³¹

In algorithmic recruitment practices we don't particularly mind about false positives (candidates who aren't a good fit) because there's an interview to filter them out.

However, the judicial risk assessments mentioned earlier might require the opposite treatment. False positives will result in parole being refused.

Selbst Abstraction: The Ripple Effect Trap

Failure to understand how the insertion of technology into an existing social system changes the behaviors and embedded values of the pre-existing system

Selbst et al³¹ depend entirely on the judicial risk assessments example for this. Their increased use focuses the intent of the justice review system to incapacitation.

Selbst Abstraction: The Solutionism Trap

Failure to recognize the possibility that the best solution to a problem may not involve technology

Modeling requires pinning down definitions. Code calcifies. When fairness is a politically contested, movable issue, a model may not be able to capture the facets of how it moves

COMPAS: Algorithmic risk assessments

COMPAS: Algorithmic risk assessments

The algorithmic risk assessment algorithm we've discussed is called COMPAS.

It's been subject to **intensive** study.

ProPublica's study in 2016³³ was one of the first investigations. A technical breakdown of this is provided by the same authors³⁴.

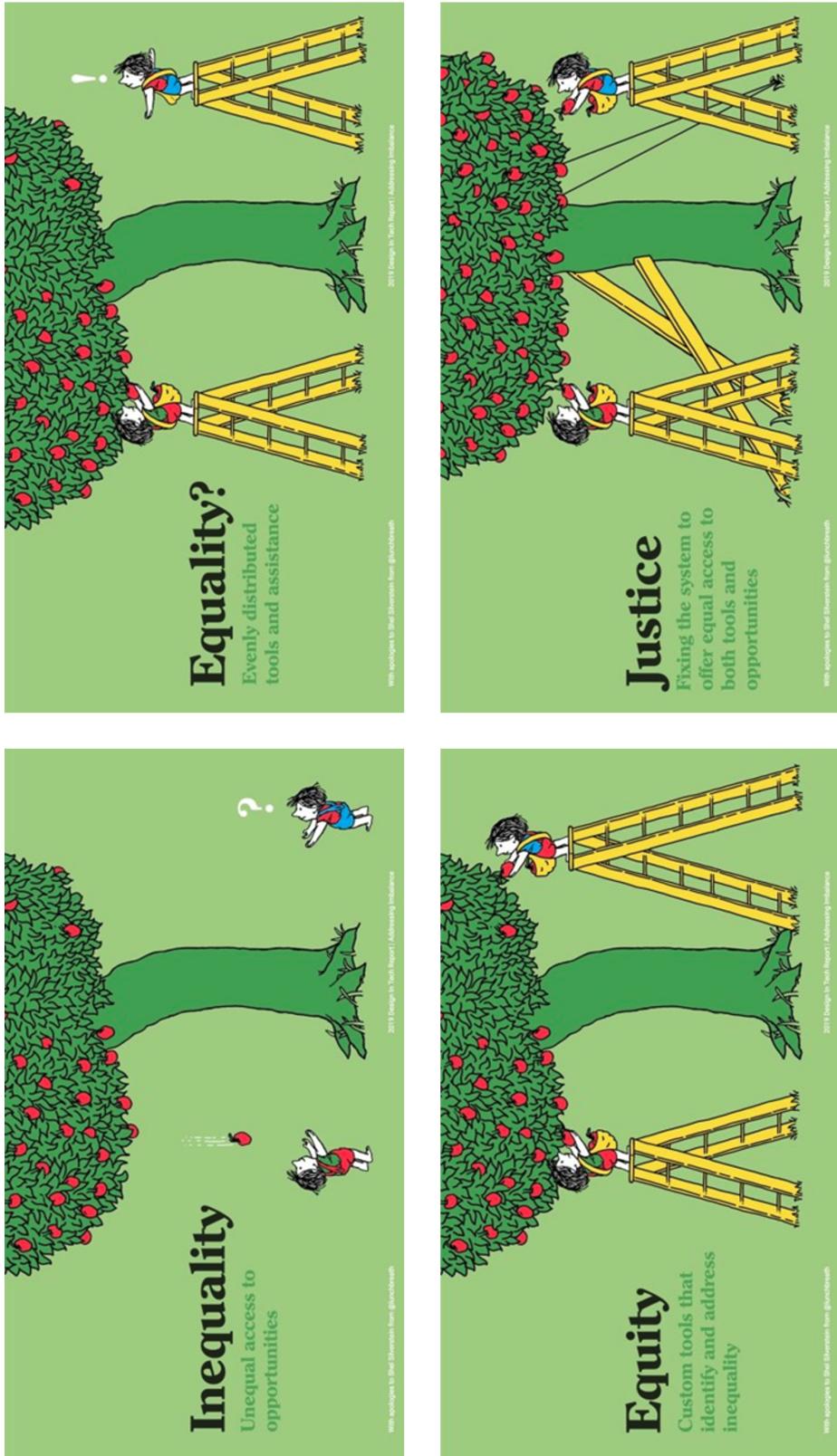
ACCURACY	
RISK score:	65.2%
HUMAN*:	67.0%
FALSE POSITIVE*	
Black:	37.1%
White:	27.2%
FALSE NEGATIVE*	
Black:	29.2%
White:	40.2%

The algorithm performs worse than 400 random Mechanical Turk users³⁵. I'd like to show you Hany Farid's TED talk on this topic³⁶.

Inequality vs Justice

Inequality vs Justice

I thought it was important to not skip over the continuum beyond inequality and justice.
These cartoons are from John Maeda's presentation on **Design in Tech Report 2019³⁷** and designed by **Tony Ruth**.



We have to stop somewhere

We have to stop somewhere

We've covered more than enough for your assessment and to get a feel for the complexities of ethics in algorithms.

We didn't really discuss data privacy very much. I'd recommend reading about the OECD Fair Information Practices.

References

1. Sucholutsky, I. & Schonlau, M. “**Less Than One**”-Shot Learning: Learning N Classes From M < N Samples. *Proceedings of the AAAI Conference on Artificial Intelligence* **35**, 9739–9746 (2021).
2. United Nations General Assembly. Universal Declaration of Human Rights. (1948).
3. Awad, E. *et al.* The Moral Machine experiment. *Nature* **563**, 59–64 (2018).
4. Maxmen, A. **Self-driving car dilemmas reveal that moral choices are not universal**. *Nature* **562**, 469–470 (2018).
5. Schoettle, B. & Sivak, M. A Preliminary Analysis of Real-World Crashes Involving Self-Driving Vehicles. (2015).
6. National Transport Safety Board. Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona, March 18, 2018. (2018).
7. Hardt, M. Occupy Algorithms: Will Algorithms Serve the 99%? (2013).
8. Barocas, S. & Selbst, A. D. Big Data’s Disparate Impact. (2016) doi:[10.2139/ssrn.2477899](https://doi.org/10.2139/ssrn.2477899).
9. Landeau, A. Explaining Bias in Your Data. (2020).
10. Goldfain, C. Sources of unintended bias in training data. *Medium* (2020).
11. Jernigan, C. & Mistree, B. F. T. Gaydar: Facebook friendships expose sexual orientation. *First Monday* (2009) doi:[10.5210/fm.v14i10.2611](https://doi.org/10.5210/fm.v14i10.2611).
12. Ensign, D., Friedler, S. A., Neville, S., Scheidegger, C. & Venkatasubramanian, S. Runaway Feedback Loops in Predictive Policing. (2017) doi:[10.48550/arXiv.1706.09847](https://doi.org/10.48550/arXiv.1706.09847).
13. Lazer, D., Kennedy, R., King, G. & Vespignani, A. The Parable of Google Flu: Traps in Big Data Analysis. *Science* **343**, 1203–1205 (2014).
14. Ginsberg, J. *et al.* Detecting influenza epidemics using search engine query data. *Nature* **457**, 1012–1014 (2009).
15. Cook, S., Conrad, C., Fowlkes, A. L. & Mohebbi, M. H. Assessing Google Flu Trends Performance in the United States during the 2009 Influenza Virus A (H1N1) Pandemic. *PLOS ONE* **6**, e23610 (2011).
16. Fraij, J. & László, V. A literature Review: Artificial Intelligence Impact on the Recruitment Process. *International Journal of Engineering and Management Sciences* **6**, 108–119 (2021).
17. Siddique, H. Minority ethnic Britons face ‘shocking’ job discrimination. *The Guardian* (2019).
18. Stauffer, J. M. & Buckley, M. R. The Existence and Nature of Racial Bias in Supervisory Ratings. *Journal of Applied Psychology* **90**, 586–591 (2005).
19. rogers, tony. Falsehoods Programmers Believe About Names - With Examples. *Shine Solutions Group* (2018).

20. Bolukbasi, T., Chang, K.-W., Zou, J., Saligrama, V. & Kalai, A. Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings. (2016) doi:[10.48550/arXiv.1607.06520](https://doi.org/10.48550/arXiv.1607.06520).
21. Mikolov, T., Chen, K., Corrado, G. S. & Dean, J. A. Computing numeric representations of words in a high-dimensional space. (2015).
22. Google. Real Tone on Google Pixel. *Google Store* (2022).
23. Roth, L. **Looking at Shirley, the Ultimate Norm: Colour Balance, Image Technologies, and Cognitive Equity.** *Canadian Journal of Communication* **34**, 111–136 (2009).
24. Monk, E. P., Jr. **The Uneasing Significance of Colorism: Skin Tone Stratification in the United States.** *Daedalus* **150**, 76–90 (2021).
25. Ward, W. H., Lambreton, F., Goel, N., Yu, J. Q. & Farma, J. M. TABLE 1, Fitzpatrick Classification of Skin Types I through VI. (2017).
26. Vox. Color film was built for white people. Here's what it did to dark skin. (2015).
27. Lewis, S. The Racial Bias Built Into Photography. *The New York Times* (2019).
28. MIT Media Lab. Gender Shades. (2018).
29. European Parliament. Directorate General for Parliamentary Research Services. *A governance framework for algorithmic accountability and transparency.* (Publications Office, 2019).
30. Caplan, R., Donovan, J., Hanson, L. & Matthews, J. Algorithmic Accountability: A primer. (2018).
31. Selbst, A. D., Boyd, D., Friedler, S. A., Venkatasubramanian, S. & Vertesi, J. Fairness and Abstraction in Sociotechnical Systems. in *Proceedings of the Conference on Fairness, Accountability, and Transparency* 59–68 (Association for Computing Machinery, 2019). doi:[10.1145/3287560.3287598](https://doi.org/10.1145/3287560.3287598).
32. Hao, K. This is how AI bias really happens and why it's so hard to fix. *MIT Technology Review* (2019).
33. Mattu, L. K., Jeff Larson. Machine Bias. *ProPublica* (2016).
34. Mattu, L. K., Julia Angwin. How We Analyzed the COMPAS Recidivism Algorithm. *ProPublica* (2016).
35. Dressel, J. & Farid, H. **The accuracy, fairness, and limits of predicting recidivism.** *Science Advances* **4**, eaao5580 (2018).
36. TEDx Talks. The danger of predictive algorithms in criminal justice | Hany Farid | TEDxAmoskeagMillyard. (2018).
37. Maeda, J. Presentation: Design in Tech Report 2019. *Design in Tech* (2019).