

CS 4530

Fundamentals of Software Engineering

## Module 18: Engineering Software for Equity

---

Adeel Bhutta, Jan Vitek, Mitch Wand  
Khoury College of Computer Sciences

# Learning Goals

---

By the end of this lesson, you should be able to...

- ◉ Illustrate how software can cause inadvertent harm or amplify inequities
- ◉ Explain the role of software engineers in avoiding such harms

# Code of Ethics

## Professional Engineers

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.



# Code of Ethics

## Professional Engineers: Citigroup Center

- Design met building code, but did *not* account for all failure modes
- Last-minute changes to construction increased odds of failure
- Fixed before disaster could strike, but kept a secret for 20 years



[https://en.wikipedia.org/wiki/Citicorp\\_Center\\_engineering\\_crisis](https://en.wikipedia.org/wiki/Citicorp_Center_engineering_crisis)

# Badly-engineered software can kill people

## Therac-25 (1985-1987)

- Bug in software caused 100x greater exposure to radiation than intended
- At least 6 died
- Likely far more suffered: deaths occurred over a period of 2 years!
- Weak accountability in manufacturer's organization



# ACM's Code of Ethics Software Engineers

1. PUBLIC – Software engineers shall act consistently with the public interest.
2. CLIENT AND EMPLOYER – Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.
- 3.
4. 1. PUBLIC – Software engineers shall act consistently with the public interest.
5. MANAGEMENT – Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.
6. PROFESSION – Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.
7. COLLEAGUES – Software engineers shall be fair to and supportive of their colleagues.
8. SELF – Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

# Equity and Software

---

*As new as software engineering is,  
we're newer still at understanding its impact on underrepresented  
people and diverse societies*

*We must recognize imbalance of power between those who make  
development decisions that impact the world  
and those who simply must accept and live with those decisions that  
sometimes disadvantage already marginalized communities globally*

# Recognize inequities in your software

---



*One mark of an exceptional engineer is the ability to understand how products can advantage and disadvantage different groups of human beings*

*Engineers are expected to have technical aptitude, but they should also have the discernment to know when to build something and when not to*

**Demma Rodriguez**  
**Head of Equity Engineering**  
**Google**



# Recognize inequities in your software

---

- ⦿ Good engineers understand how products can be weaponized to create harms in certain groups
- ⦿ Microsoft failed with a chatbot that picked up the behavior people used...
- ⦿ ...they taught Tay to use offensive and racist language attacking jews



# Recognize inequities in your software

---

- ◉ Good engineers understand how products can be weaponized...
- ◉ Amazon failed with their AI hiring software...
- ◉ ...it used 10 years of resumes to learn who should be hired
- ◉ ...it learned to automatically reject the resumes of women



# Algorithmic sentencing discriminates

The COMPAS sentencing tool discriminates against black defendants

	ALL	WHITE DEFENDANTS	<b>BLACK</b> DEFENDANTS
Labeled <b>High Risk</b> , But <b>Didn't</b> Re-Offend	<b>32%</b>	<b>23%</b>	<b>44%</b>
Labeled <b>Low Risk</b> , Yet <b>Did</b> Re-Offend	<b>37%</b>	<b>47%</b>	<b>28%</b>

# Algorithmic bias discriminates

...against the poorest of us

THE WALL STREET JOURNAL.

## Websites Vary Prices, Deals Based on Users' Information

### Getting Different Deals Online

A Journal examination found online retailers adjusted prices by a shopper's location, among other factors

**Staples.com**  
SnapSafe Titan safe

HIGHER PRICE

\$1,199.99

DISCOUNT PRICE

\$1,099.99

DIFFERENCE:

9.1%

**Homedepot.com**

A 250-foot spool of electrical wiring



Six pricing groups, including:

\$70.80 in Ashtabula, Ohio

\$72.45 in Erie, Pa.

\$77.87 in Monticello, N.Y.

**Rosettastone.com**



...for buying multiple levels of German lessons, when test-shopping from the U.S. or Canada. But not from the U.K. or Argentina.

Photos: l to r: SnapSafe; Home Depot; Rosetta Stone Source: WSJ testing

The Wall Street Journal

## FairTest: Discovering Unwarranted Associations in Data-Driven Applications\*

Florian Tramèr<sup>1</sup>, Vaggelis Atlidakis<sup>2</sup>, Roxana Geambasu<sup>2</sup>, Daniel Hsu<sup>2</sup>,  
Jean-Pierre Hubaux<sup>3</sup>, Mathias Humbert<sup>4</sup>, Ari Juels<sup>5</sup>, Huang Lin<sup>3</sup>

<sup>1</sup>Stanford, <sup>2</sup>Columbia University, <sup>3</sup>EPFL, <sup>4</sup>Saarland University, <sup>5</sup>Cornell Tech, Jacobs Institute

**Abstract**—In a world where traditional notions of privacy are increasingly challenged by the myriad companies that collect and analyze our data, it is important that decision-making entities are held accountable for unfair treatments arising from irresponsible data usage. Unfortunately, a lack of appropriate methodologies and tools means that even identifying unfair or discriminatory effects can be a challenge in practice.

We introduce the *unwarranted associations (UA) framework*, a principled methodology for the discovery of unfair, discriminatory, or offensive user treatment in data-driven applications. The UA framework unifies and rationalizes a number of prior attempts at formalizing algorithmic fairness. It uniquely combines multiple investigative primitives and fairness metrics with broad applicability, granular exploration of unfair treatment in user subgroups, and incorporation of natural notions of utility that may account for observed disparities.

We instantiate the UA framework in *FairTest*, the first comprehensive tool that helps developers check data-driven applications for unfair user treatment. It enables scalable and statistically rigorous investigation of associations between application outcomes (such as prices or premiums) and sensitive user attributes (such as race or gender). Furthermore, *FairTest* provides *debugging capabilities* that let programmers rule out

decision-making can have unintended and harmful consequences, such as unfair or discriminatory treatment of users.

In this paper, we deal with the latter challenge. Despite the personal and societal benefits of today's data-driven world, we argue that companies that collect and use our data have a responsibility to ensure equitable user treatment. Indeed, European and U.S. regulators, as well as various policy and legal scholars, have recently called for increased *algorithmic accountability*, and in particular for decision-making tools to be audited and “tested for fairness” [1], [2].

There have been many recent reports of unfair or discriminatory effects in data-driven applications, mostly qualified as unintended consequences of data heuristics or overlooked bugs. For example, Google's image tagger was found to associate racially offensive labels with images of black people [3]; the developers called the situation a bug and promised to remedy it as soon as possible. In another case [4], *Wall Street Journal* investigators showed that Staples' online pricing algorithm discriminated against lower-income people. They referred to the situation as an “unintended consequence” of Staples's seemingly rational decision to adjust online prices based on user proximity to competitors' stores. This led to higher prices for low-income customers who generally live farther from these stores

# Training AI systems impacts climate



{\* AI + ML \*}

## AI me to the Moon... Carbon footprint for 'training GPT-3' same as driving to our natural satellite and back

Get ready for Energy Star stickers on your robo-butlers, maybe?

Katyanna Quach Wed 4 Nov 2020 // 07:59 UTC

SHARE

Training OpenAI's giant GPT-3 text-generating model is akin to driving a car to the Moon and back, computer scientists reckon.

More specifically, they estimated teaching the **neural super-network** in a Microsoft data center using Nvidia GPUs required roughly 190,000 kWh, which using the average carbon intensity of America would have produced 85,000 kg of CO<sub>2</sub> equivalents, the same amount produced by a new car in Europe driving 700,000 km, or 435,000 miles, which is about twice the distance between Earth and the Moon, some 480,000 miles.

Phew.

[https://www.theregister.com/2020/11/04/gpt3\\_carbon\\_footprint\\_estimate/](https://www.theregister.com/2020/11/04/gpt3_carbon_footprint_estimate/)

### Consumption

### CO<sub>2</sub>e (lbs)

Air travel, 1 passenger, NY↔SF	1984
Human life, avg, 1 year	11,023
American life, avg, 1 year	36,156
Car, avg incl. fuel, 1 lifetime	126,000

### Training one model (GPU)

NLP pipeline (parsing, SRL)	39
w/ tuning & experimentation	78,468
Transformer (big)	192
w/ neural architecture search	626,155

["Energy and Policy Considerations for Deep Learning in NLP"](#)  
by Strubell et al in ACL19

# UIs discriminate against differently-abled

Inclusivity and Accessibility: Domino's Pizza LLC v. Robles

## Domino's Would Rather Go to the Supreme Court Than Make Its Website Accessible to the Blind

Rather than developing technology to support users with disabilities, the pizza chain is taking its fight to the top

by Brenna Houck | @EaterDetroit | Jul 25, 2019, 6:00pm EDT

f   SHARE

["Domino's Would Rather Go to the Supreme Court Than Make Its Website Accessible to the Blind" by Brenna Houck, Eater Detroit](#)



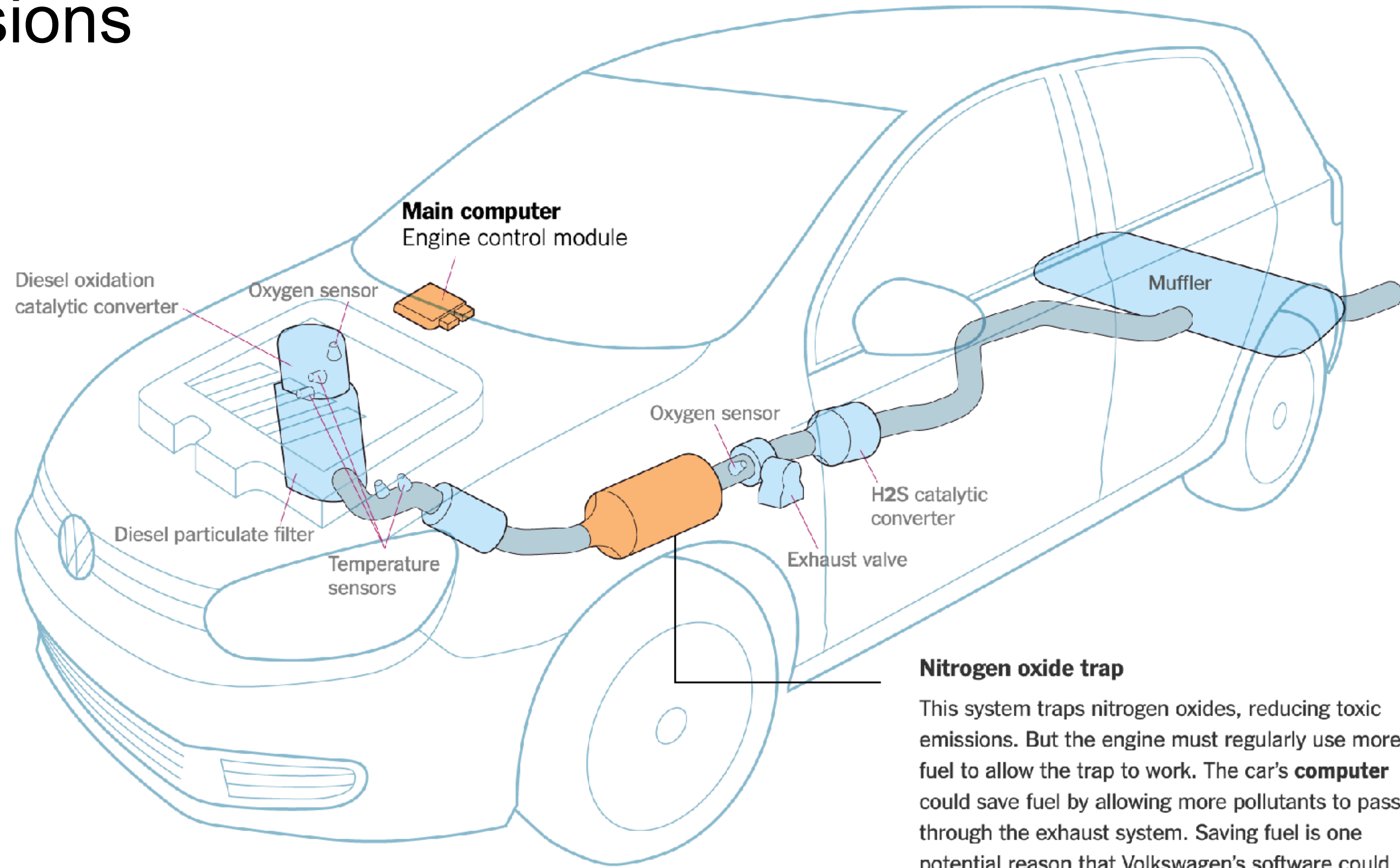
Jul 15 2019	<b>Brief amicus curiae of Washington Legal Foundation filed.</b>
Jul 15 2019	<b>Brief amici curiae of Retail Litigation Center, Inc., et al. filed.</b>
Jul 15 2019	<b>Brief amicus curiae of Cato Institute filed.</b>
Jul 15 2019	<b>Brief amicus curiae of Restaurant Law Center filed.</b>
Jul 15 2019	<b>Brief amici curiae of Chamber of Commerce of the United States of America, et al. filed.</b>

# Software evades regulation

## Example: Volkswagen diesel emissions

### The Emissions Tests That Led to the Discovery of VW's Cheating

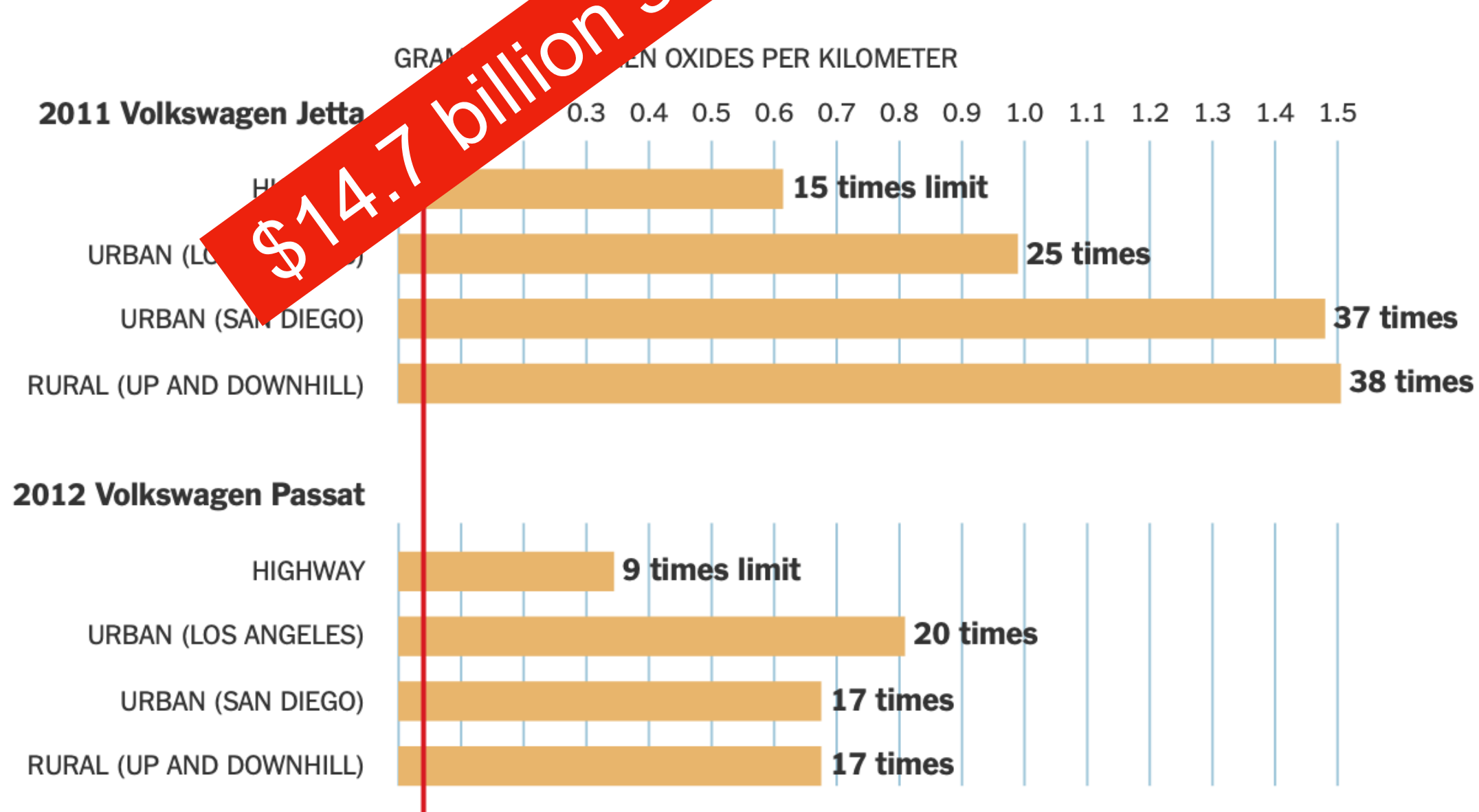
The on-road testing in May 2014 that led the California Air Resources Board to investigate Volkswagen was conducted by researchers at West Virginia University. They tested emissions from two VW models equipped with the 2-liter turbocharged 4-cylinder diesel engine. The researchers found that when tested on the road, some cars emitted almost **40 times** the permitted level of nitrogen oxides.



**Nitrogen oxide trap**  
 This system traps nitrogen oxides, reducing toxic emissions. But the engine must regularly use more fuel to allow the trap to work. The car's **computer** could save fuel by allowing more pollutants to pass through the exhaust system. Saving fuel is one potential reason that Volkswagen's software could have been altered to make cars pollute more, according to researchers at the International Council on Clean Transportation.

Illustration by Guilbert Gates | Source: Volkswagen, The International Council on Clean Transportation

Average emissions of nitrogen oxides on-road testing



\$14.7 billion settlement

U.S. limit

# Bias is the Default

## Example: Google Photos auto-tagging



THE WALL STREET JOURNAL.



DIGITS

### Google Mistakenly Tags Black People as ‘Gorillas,’ Showing Limits of Algorithms

By [Alistair Barr](#)

Updated July 1, 2015 3:41 pm ET

SHARE TEXT

Google is a leader in artificial intelligence and machine learning. But the company’s computers still have a lot to learn, judging by a major blunder by its Photos app this week.

The app tagged two black people as “Gorillas,” according to Jacky Alciné, a Web developer who spotted the error and tweeted a photo of it.

“Google Photos, y’all f\*\*ked up. My friend’s not a gorilla,” [he wrote on Twitter](#).

<https://www.wsj.com/articles/BL-DGB-42522>

<https://www.wired.com/story/when-it-comes-to-gorillas-google-photos-remains-blind/>

WIRED

BACKCHANNEL BUSINESS CULTURE GEAR IDEAS MORE

SIGN IN



TOM SIMONITE

BUSINESS 01.11.2018 07:00 AM

### When It Comes to Gorillas, Google Photos Remains Blind

Google promised a fix after its photo-categorization software labeled black people as gorillas in 2015. More than two years later, it hasn't found one.



In WIRED's tests, Google Photos did identify some primates, but no gorillas like this one were to be found. RICK MADONIK/TORONTO STAR/GETTY IMAGES

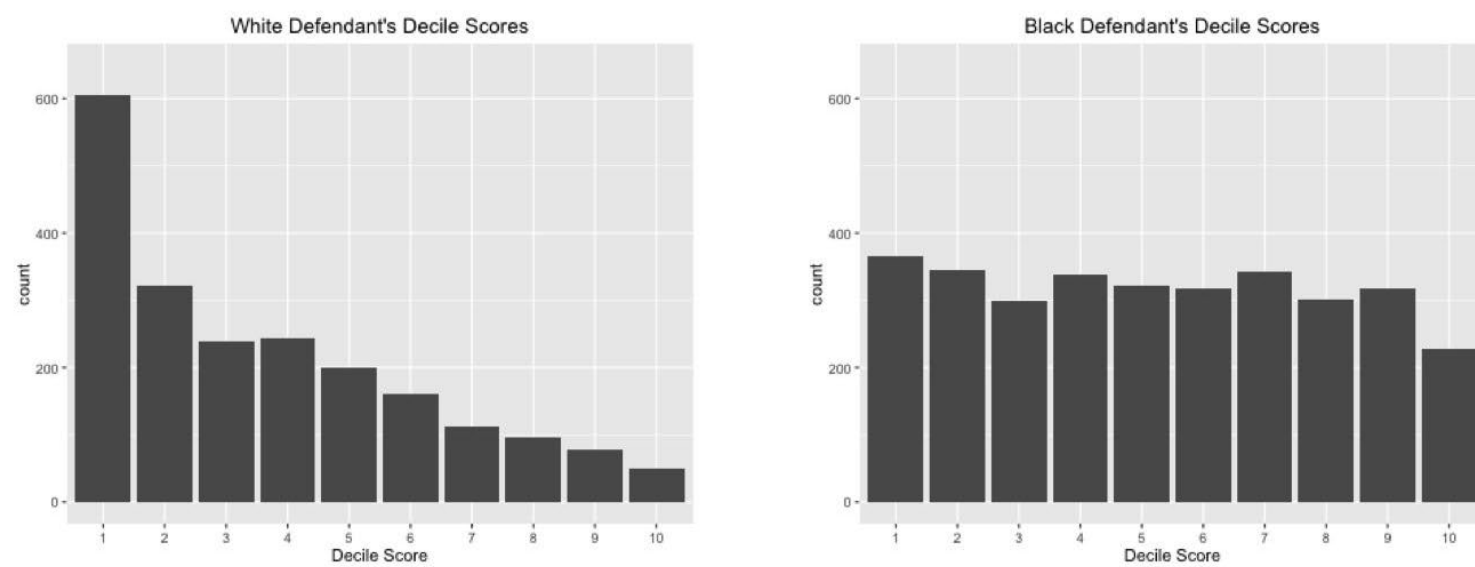


# Reflecting on these examples

## Personal philosophies and business cases

### Algorithmic Bias: COMPAS Sentencing Tool

	ALL DEFENDANTS	WHITE DEFENDANTS	BLACK DEFENDANTS
Labeled Higher Risk, But Didn't Re-Offend	32.4%	23.5%	44.9%
Labeled Lower Risk, Yet Did Re-Offend	37.4%	47.7%	28.0%



Analysis of Broward County, FL data: "How We Analyzed the COMPAS Recidivism Algorithm" by Jeff Larson, Surya Mattu, Lauren Kirchner and Julia Angwin

### Algorithmic Bias: Price Discrimination

By Jennifer Valentino-DeVries, Jeremy Singer-Vine and Ashkan Soltani  
December 24, 2012  
<https://www.wsj.com/articles/SB1000142412788732377204578189391813881534>

### Inclusivity and Accessibility: Domino's Pizza LLC v. Robles

#### Domino's Would Rather Go to the Supreme Court Than Make Its Website Accessible to the Blind

Rather than developing technology to support users with disabilities, the pizza chain is taking its fight to the top

by Brenna Houck | @EaterDetroit | Jul 25, 2019, 6:00pm EDT

f t SHARE



Jul 15 2019	Brief amicus curiae of Washington Legal Foundation filed.
Jul 15 2019	Brief amici curiae of Retail Litigation Center, Inc., et al. filed.
Jul 15 2019	Brief amicus curiae of Cato Institute filed.
Jul 15 2019	Brief amicus curiae of Restaurant Law Center filed.
Jul 15 2019	Brief amici curiae of Chamber of Commerce of the United States of America, et al. filed.

"Domino's Would Rather Go to the Supreme Court Than Make Its Website Accessible to the Blind" by Brenna Houck, Eater Detroit

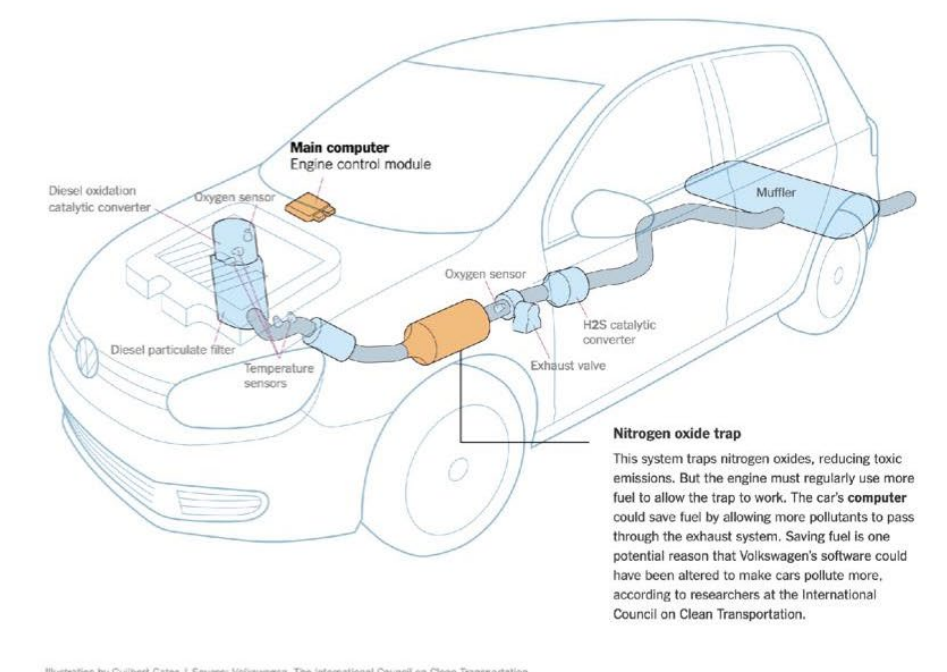
### Evading regulation: Volkswagen

#### The Emissions Tests That Led to the Discovery of VW's Cheating

The on-road testing in May 2014 that led to the California Air Resources Board to investigate Volkswagen was conducted by researchers at West Virginia University. They tested emissions from two VW Golf GTIs equipped with the 2-liter turbocharged 4-cylinder diesel engine. The cars were tested on a dynamometer and when tested on the road, some cars emitted almost 40 times the allowed levels of nitrogen oxides.



"How Volkswagen's 'Defeat Devices' Worked" By Guilbert Gates, Jack Ewing, Karl Russell and Derek Watkins



# More than *don't be evil*

---

Engineering equitable software requires conscious effort

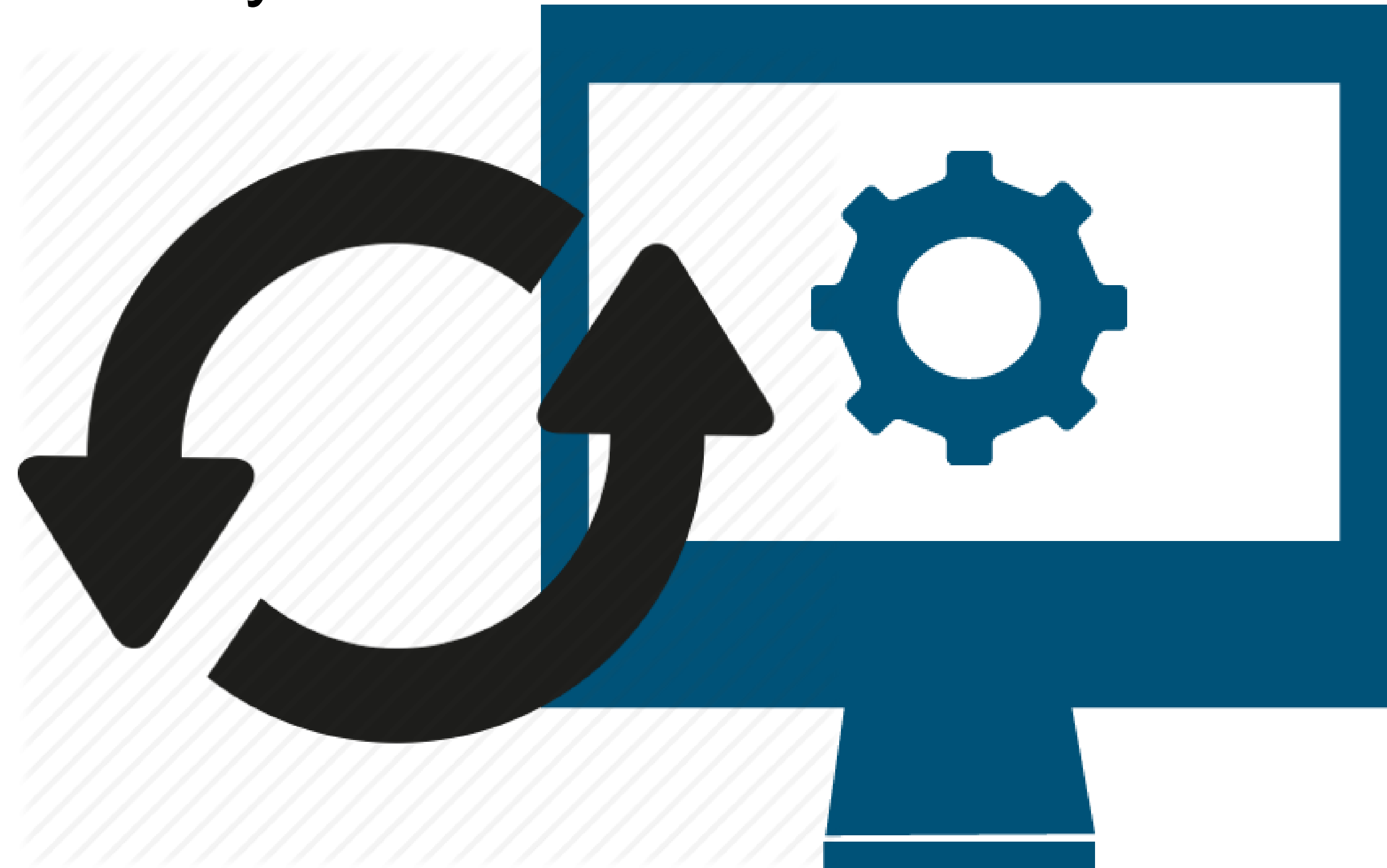
- ⦿ How do we determine what “the right thing” is?
- ⦿ How do we convince our investors/managers to take this action?

# How to mitigate harms in software?

---

What are you trying to solve?

- ◉ For every software you create, include a wide range of people to use it
- ◉ Including more people helps detect biases and harms
- ◉ Iterate your software throughout its entire life cycle.



# How to write software for people that mitigates harm



Microsoft

1

INITIALLY

Make clear what the system can do

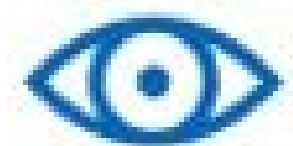
Help the users understand what the AI system is capable of doing.

2

INITIALLY

Make clear how well the system can do what it can do.

Help the user understand how often the AI system may make mistakes.



INITIALLY

---



Microsoft

3

DURING INTERACTION

**Time services based on context.**

Time when to act or interrupt based on the user's current task and environment.

4

DURING INTERACTION

**Show contextually relevant information.**

Display information relevant to the users' current task and environment.

5

DURING INTERACTION

**Match relevant social norms.**

Ensure the experience is delivered in a way that users would expect, given their social and cultural context.

6

DURING INTERACTION

**Mitigate social biases.**

Ensure the AI system's language and behaviors do not reinforce undesirable and unfair stereotypes and biases.



**DURING INTERACTION**

---



Microsoft

7

WHEN WRONG

### Support efficient invocation.

Make it easy to invoke or request the AI system's services when needed.

8

WHEN WRONG

### Support efficient dismissal.

Make it easy to dismiss or ignore undesired system services.

9

WHEN WRONG

### Support efficient correction.

Make it easy to edit, refine, or recover when the AI system is wrong.

10

WHEN WRONG

### Scope services when in doubt.

Engage in disambiguation or gracefully degrade the AI system's services when uncertain about a user's goals.

11

WHEN WRONG

### Make clear why the system did what it did.

Enable the user to access an explanation of why the AI system behaved as it did.

 **WHEN WRONG**

---

12  
OVER TIME

### Remember recent interactions.

Maintain short-term memory and allow the user to make efficient references to that memory.

13  
OVER TIME

### Learn from user behavior.

Personalize the user's experience by learning from their actions over time.

14  
OVER TIME

### Update and adapt cautiously.

Limit disruptive changes when updating and adapting the AI system's behaviors.

15  
OVER TIME

### Encourage granular feedback.

Enable the user to provide feedback indicating their preferences during regular interaction with the AI system.

16  
OVER TIME

### Convey the consequences of user actions.

Immediately update or convey how user actions will impact future behaviors of the AI system.

## 🕒 OVER TIME

---

17  
OVER TIME

### Provide global controls.

Allow the user to globally customize what the AI system monitors and how it behaves.

18  
OVER TIME

### Notify users about changes.

Inform the user when the AI system adds or updates its capabilities.



# Where does this leave us?

---

## So that we can sleep at night

- ◉ Consider the different ways that our software may **impact** others
- ◉ Consider the ways in which our software **interacts** with the political, social, and economic systems in which we and our users live
- ◉ Follow **best practices**, and actively push to improve them
- ◉ Encourage **diversity** in our development teams
- ◉ Engage in **honest conversations** with our co-workers and supervisors to explore possible ethical issues and their implications.

# Learning Goals

---

You should now be able to...

- ◉ Suggest how software can cause inadvertent harm or amplify inequities
- ◉ Explain why software engineers have a role to play in avoiding such harms

# Exercise

---

Team up and propose actionable ideas to re-design Amazon's Hiring Software

