COMPUTER ALGORITHMS AND THEIR INHERENT SOCIAL BIAS

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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INCREASING USE AND RELIANCE ON COMPUTER ALGORITHMS

“I do not fear computers. I fear the lack of them” (Asimov, 1978, para. 1). This mentality to turn to technology and embrace it as an omnipotent artifact was made famous by American writer Isaac Asimov. Due to this mindset, when society is faced with a problem, most people prefer to turn to technology as a fix. This is apparent in the case of using computer algorithms to expedite certain tasks such as scanning through and selecting resumes. Although this might seem harmless, it is improbable that these computer algorithms are selecting resumes without bias. Amazon experimented with AI algorithms to do just this and found that an overwhelming number of male candidates were selected over women candidates (Dastin, 2018). Other examples include facial recognition and stock market algorithmic trading. There are even the more severe cases where colleges go so far as to rank prospective students based on computer algorithms. These computer algorithms are becoming more widespread with the growth of information technology. According to the research consultancy International Data Corporation (IDC), the global information technology industry will reach $5.2 trillion in 2020 (IDC, n.d., para. 1). Other estimates show that one quarter of GDP growth in the European Union and 40 percent of productivity growth can be attributed to information and communications technology (Wessner, 2011, para. 10). As new software technologies and computer algorithms continue to grow, the need to protect from their harmful effects on society becomes increasingly necessary

The problem can be mapped from a lack of technological literacy and lack of government regulation. The International Technology and Engineering Educators Association (ITEEA) defines technological literacy as “one's ability to use, manage, evaluate, and understand technology” (ITEEA, 2020, para. 1). ITEEA goes on to say that it should be a person’s duty to know how technology works, how it shapes society and in turn how society shapes it (ITEEA, 2020, para. 2). This lack of technological literacy is what allows social discriminatory computer algorithms to exist. Another problem would be the little government regulation in the software development field. Currently, there is no government regulatory agency dedicated specifically to regulate software algorithms (USAGov, n.d.). Whether this is from a lack of funding or a lack of awareness, the problem needs to be addressed. How can we make sure computer algorithms developed have little to no unintended social bias? This paper will aim to propose a viable solution by imposing guidelines and regulation software development entities would follow. It will outline a solution that is based on an increased interaction between relevant stakeholders. This will be done through Actor Network Theory (Latour, 2005) and mapping interactions with actors such as computer ethics testers. By subcategorizing stakeholders into different networks, an ideal relationship between all the networks can be abstracted and connections between the three networks can be visualized. The solution to the problem will rely on increased accountability from software developers, awareness of unintended uses of computer algorithms, and greater government regulation. It will seek to change the status quo of current software development practices and introduce government intervention into the software development environment.

The technical research portion of this paper (Gesture Watch) will consist of a watch that registers gesture commands made by a user and performing an operation with a paired device. An example of its intended use would be advancing a presentation slide by swiping left or right with a sweeping arm movement. Although the Gesture Watch has a computer/software algorithm built into the microcontroller, none of the algorithms have any social consequence. The software is designed in order to meet only its use cases, and functionality of the watch is disabled when not in use in order to eliminate unintended consequences that could cause bias. Every computer algorithm is created in order to solve a societal problem. However, while the computer algorithm might solve the initial problem that it sought to fix, other problems could arise, especially in the realm of social discrimination. The gesture watch will serve to facilitate an easier means of performing functions remotely while also trying to avoid potential bias.

UNINTENDED SOCIAL BIAS OF COMPUTER ALGORITHMS

One of the most glaring issues with computer algorithms is their potentially unintended negative effects on human society. This is immediately apparent when it comes to facial recognition software. Facial recognition software in particular falsely identifies African American and Asian faces 10 to 100 times more than Caucasian faces (Metz & Singer, 2019). Even though this is a widely known statistic, it is not illegal to produce and use the software and whether or not facial recognition should be used is an ethical dilemma.

Other cases of socially biased software include universities using students' personal data, such as web-browsing habits and financial history to determine admissions. A 2019 report by The Washington Post showed that:

> Admissions officers at the University of Wisconsin-Stout turned to a little-known but increasingly common practice: They installed tracking software on their school website. The software sent an alert to the school's assistant director of admissions containing the student's name, contact information and details about her life and activities on the site, according to internal university records reviewed by The Washington Post. The email said she was a graduating high school senior in Little Chute, Wis., of Mexican descent who had applied to UW-Stout. A map on this page showed her geographical location, and an "affinity index" estimated her level of interest in attending the school. Her score of 91 out of 100 predicted she was highly likely to accept an admission offer from UW-Stout, the records showed (Anderson, N & MacMillan, D., 2019, para 1-2).

Although profiling students based on digital tracking might violate the Family Educational Rights and Privacy Act (FERPA), a federal law protecting the privacy of student education records at schools that receive federal education funds (Family Educational Rights and Privacy Act, 1974), little has been done to enforce this violation. School admissions officers freely use computer algorithms to rank and categorize students based on their race, location, affinity, and other information that is unknowingly tracked.

Another example is stock market algorithmic trading. Stock market algorithmic trading is believed to give big banks an unfair advantage over regular investors by increasing market volatility and triggering sell orders (Krause, 2020). Over the years, the highest one-day net change in percentage of the Dow Jones Industrial Average (DJI) has increased drastically. Figure 1 shows the daily net change in USD of the DJI from 2000-10 and 2020. The data from 2020 shows a much greater net change occurrence across the board compared to the data from 2000-10. This change can partially be attributed to the increased reliance on algorithmic trading and automatic buying and selling.

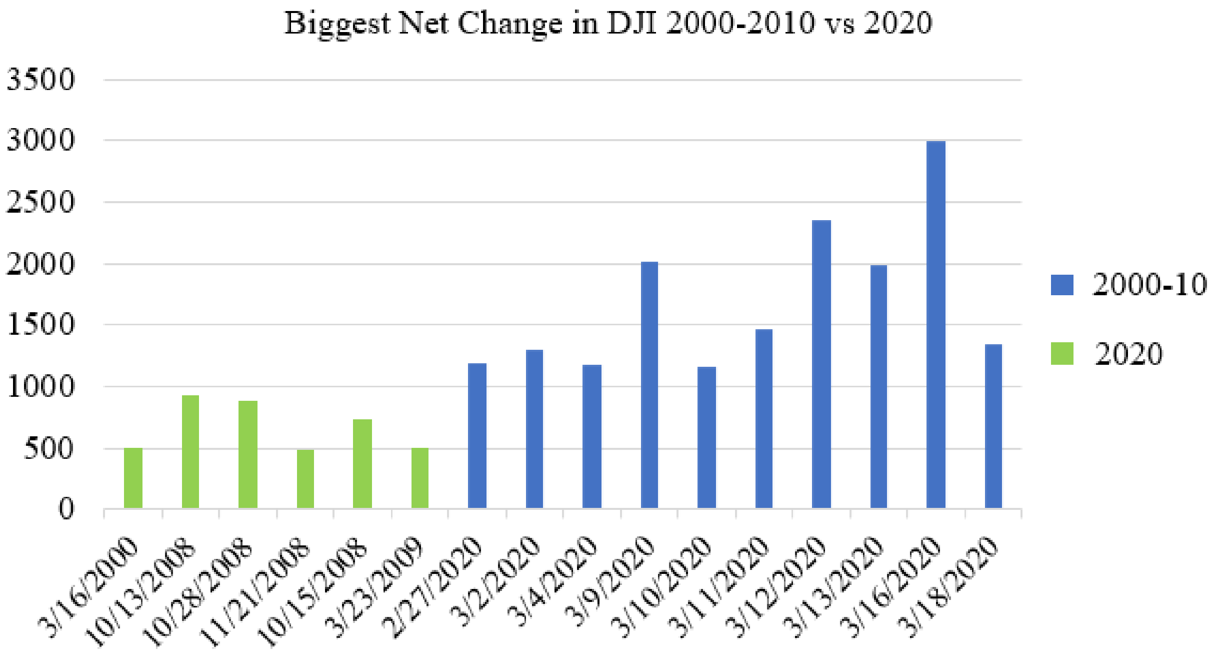

Figure 1: DJI Net Change (USD): Biggest Net Change in DJI 2000-2010 vs 2020 (Tan adapted from Indexology 2020)

This can also be seen on a day in May 2010, which wiped $860 billion from US stock markets in less than 30 minutes (Krause, 2020), something that, before the use of algorithmic trading, was deemed unprecedented.

LACK OF REGULATION AND AWARENESS

Currently, there is a lack of awareness of the unintended discriminatory effects that computer algorithms can have. In the majority of cases, discriminatory computer algorithms are only dealt with after they have caused damage. An example of this would be Amazon scraping their artificial intelligence (AI) recruiting tool (Dastin, 2018). The tool used AI to help select candidates for job interviews. It was deemed from internal data testing, that the tool preferred to select the resume of men over women. There have been attempts to limit the negative discriminatory impacts of computer algorithms. The city of San Francisco banned all government facial recognition software in 2019 after fears of potential abuse by the government that may shove the United States in the direction of an overly oppressive surveillance state (Conger et al., 2019). San Francisco is considered a hub for innovation and new technology and this ban set a precedent for the entire world as well as foreshadowed a potentially emerging problem. Although San Francisco took the initiative to enact this ban, the national government did little to address the issue. If the US federal government continues to not impose guidelines on software algorithms, there will continue to be little awareness of discriminatory software.

The problem is further exacerbated by the little to no interaction between the US government, its population, and the entities that create and publish the computer algorithm. For software development companies, the primary objective of the software is to increase profits, hence, the ethical aspects of software algorithms are sometimes ignored. Because of this, it is left to the individual software developer to act when they deem something is unethical, something that could adversely affect them if done improperly. Figure 2 is an outline of the problem in a Technological Handoff Model. It highlights the lack of intervention from the US Government in the software development field. All the ethics responsibility rests solely with the software developers and there is no entity dedicated specifically to review the ethics of the end software algorithm produced.

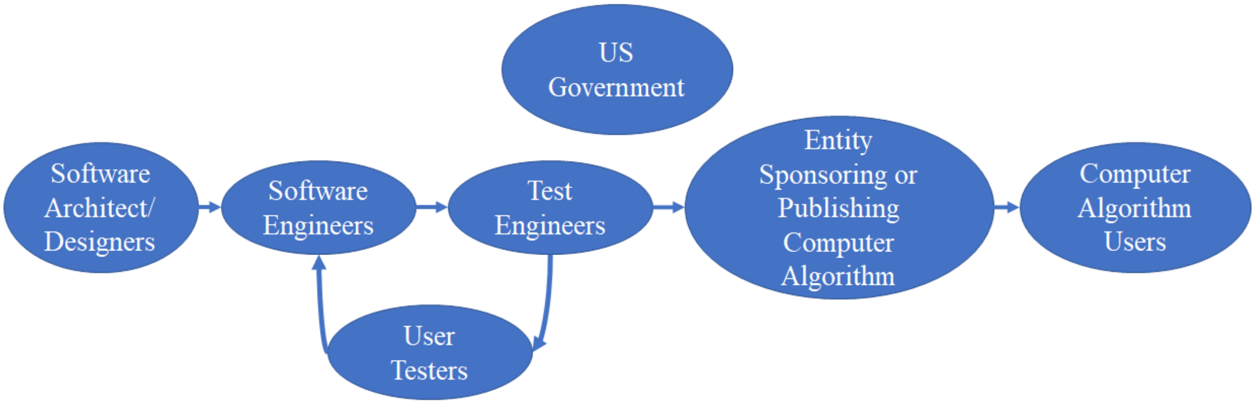

Figure 2: Technological Handoff Model: Modified Technological Handoff Model showing Computer Algorithm development (Tan, 2020)

This model also gives the potential for software development entities to be unaccountable for unethical software they create as the government does little to regulate it.

ACCOUNTABILITY, AWARENESS, AND GOVERNMENT REGULATION

The proposed solution to this problem will come in 3 steps:

(i) Accountability of entities developing computer algorithms

(ii) Citizen awareness of software technologies

(ii) Government regulation of potentially harmful software

Accountability

The first step to a solution is accountability. Parties should be held accountable for the computer algorithms that they create. When a software development entity produces software that negatively impacts others, they should be subject to some form of government fines. Accountability should also come internally by the entity publishing their computer algorithm. It should be the duty of all software development companies to have their own set of technologically literate computer ethics testers. These computer ethics testers would be responsible for performing ethics tests on the software and working with software developers to list out intended and unintended purposes of the algorithm. Currently, patents require that only novel intended uses for a software are listed under their claims and that claims cover what a device is, not what a device does (Hewlett-Packard Co. v. Bausch & Lomb Inc., 1990). It is possible that this mentality causes software development entities to overlook the unintended consequences of their software. Software algorithms pertaining to human and social interactions for example, facial recognition software, should be required to detail a list of unintended uses of the algorithm in patents. These unintended uses would outline potential social discriminatory consequences and help prevent other negative consequences that could be conceived with its use.

Awareness

Second, citizens should strive to be technologically literate and outspoken about the current and new software technology that is in existence. Awareness can start via a top down approach from the government or a bottom up approach from the general population. The sooner the national government acts and imposes guidelines on software algorithms, the more likely it is that local governments would follow suit. There would be a new government agency established in order to regulate software algorithms. This would help bridge the divide between the government and the US population. Another thing that could spread awareness is having a grade school class dedicated specifically towards teaching students about computer ethics. Although costly, it may prevent potentially society damaging consequences in the future.

A bottom up approach from the general population would also press the issue by enabling citizens to keep a watchful eye on discriminatory software. If they see a software algorithm that they deem biased, they should be able to report this to the government agency regulating software. This will require citizens to enact duty ethics to keep up with technological trends and act when they see social injustice by technology.

Government Regulation

Lastly, the government should impose guidelines and regulations for all computer algorithms that have the potential to impact society. Every software algorithm that is developed and pertains to human selection and social interaction should be subject to similar regulation. The government would create guidelines for these algorithms based on the Ten Commandments of Computer Ethics, a standard put in place by the Computer Ethics Institute (1992). The software algorithms would have to pass through all ten commandments for it to be permitted for use. The commandments of particular interest would be commandment one and ten, which are "thou shalt not use a computer to harm other people (Computer Ethics Institute, 1992, para. 1)" and "thou shalt always use a computer in ways that ensure consideration and respect for other humans respectively" (Computer Ethics Institute, 1992, para. 10). Any social discriminatory acts violating these two principles would not be permitted.

Another issue to consider is computer privacy, which is often neglected by the private sector. The Privacy Act, 5 U.S.C. § 552a (1974) states that the government's need to maintain information about individuals with the rights of individuals is to be protected against unwarranted invasions. While there are privacy laws put in place for on the government side, there is little to no regulation on the private industry side. This is in part what enables socially discriminatory computer algorithms to exist. To fix this, the Privacy Act of 1974 should be extended to include private industries holding on to consumers' personal information as well. This would insure that information stored by private companies are on a need to know basis level and information is used only to provide an intended service.

Actor-Network Theory Solution

The solution will be outlined using Latour's (2005) Actor-Network Theory Model, a social theory in which there are constantly shifting networks of relationships between actors.

Figure 3 maps out how actors would ideally interact with each other to prevent unintended social discrimination from computer algorithms. In the figure, there are 3 major actor-networks (US Population, US Government, and the Software Development Entities) that would work to ensure the transparent intentions of computer algorithms. Ideally, these three actor-networks would work together and form something similar to a Technology and Social Relationship Framework, where the end user, in this case the US population, is at the center of all entities with their interests being the most paramount. The US government and software development entities would serve to continuously interact with and protect the well-being of the US population.

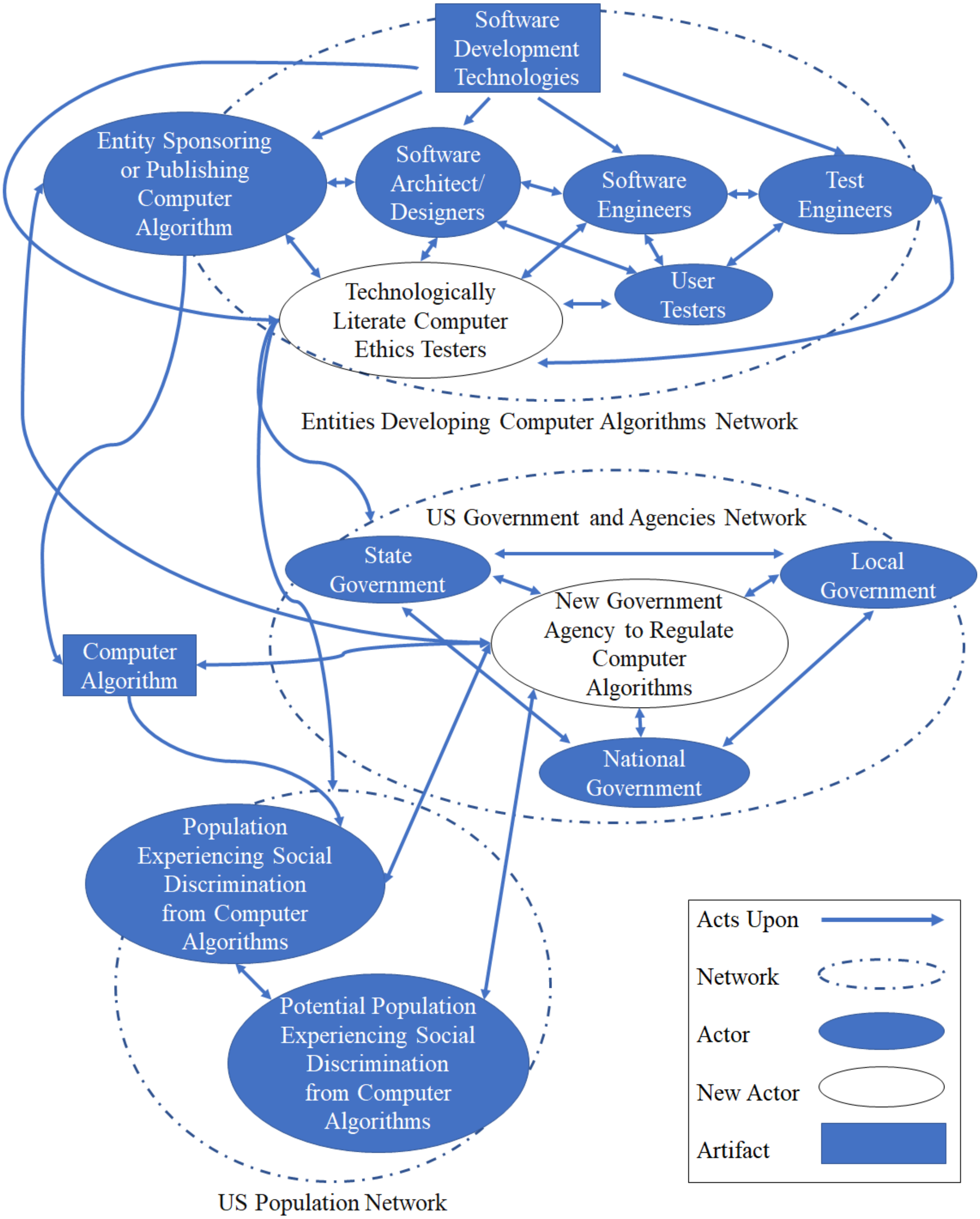
Software Development Technologies
Entity Sponsoring or Publishing Computer Algorithm
Software Architect/ Designers
Software Engineers
Test Engineers
User Testers
Technologically Literate Computer Ethics Testers
Entities Developing Computer Algorithms Network
US Government and Agencies Network
State Government
Local Government
New Government Agency to Regulate Computer Algorithms
National Government
Computer Algorithm
Population Experiencing Social Discrimination from Computer Algorithms
Potential Population Experiencing Social Discrimination from Computer Algorithms
US Population Network
Acts Upon
Network
Actor
New Actor
Artifact

Figure 3: Actor Network Theory: Actor Network Theory diagram showing the proposed relationship between the US Population, Government, and Publishing Entities (Tan, 2020)

The model introduces two new, currently nonexistent actors. It includes technologically literate computer ethics testers and a new government agency to regulate computer algorithms. It would be the responsibility of the ethics testers to internally review all the software and computer algorithms developed by entities sponsoring or publishing computer algorithms. This internal review will keep software developers accountable for the work they do. Ethics testers will also work with the US Government and Agencies to ensure that they comply with regulations. They would also be responsible for spreading awareness about computer ethics to the US population. Spreading this awareness would hopefully encourage technological literacy among the population. A new government agency would be created in order to review computer algorithms and regulate them based on its potential impact to society. They would work with the state, local, and national government to make sure regulation is enforced.

BARRIERS TO IMPLEMENTATION

There are many barriers to implementation that the proposed solution faces. The biggest one being the funding required to establish a new government agency and regulate algorithms. Another potential problem is the fact that many entities might not be on board with more regulation. There are those that believe that the government should take a more laissez-faire hand offs approach when it comes to government policies. These same people would argue that the intended benefit from government policy does not outweigh the economic loss. In an article published by the Economic Policy Institute, government regulation costs companies an estimated cost $1.75 trillion per year (Irons & Shapiro, 2011). Other numbers show that government regulation costs Americans at least $8,000 per household (Laffer, 1993). An increase in regulation would also mean greater development time for software algorithms and hence a greater potential loss in profits for software development entities. This longer development process would also affect the end consumer who might not be open to waiting a longer period of time for a product to release.

Then there are the cases that provide a contrary viewpoint. A report published by the Economic Policy Institute (2011) found that eight million jobs were lost in the Great Recession, and after months of the government allowing the population to self-regulate, the labor and housing markets remain painfully weak. “Even Alan Greenspan, chairman of the Federal Reserve Board from 1997 to 2005 and a leading proponent of market self-regulation, has admitted that this approach failed during the crisis” (Irons & Shapiro, 2011, para. 5). Alana Semuels (2017), a reporter for The Atlantic wrote an article about the effect of government regulation on jobs:

> A well-known study by the economists Eli Berman and Linda T.M. Bui (1997) of Boston University looked at the aftermath of new regulations governing air quality in Los Angeles. The South Coast Air Quality Management District in Los Angeles enacted some of the country’s most stringent air quality standards in the 1980s, and Berman and Bui compared Los Angeles firms with those in Louisiana and Texas to see if the more regulated firms cut jobs as a result. They found that the local air quality regulations were not responsible for a large decline in employment, and that the regulations might have actually increased labor demand since firms need to hire people to help them deal with the new regulations (Semuels, para. 9).

The studies conducted by Eli Berman and Linda T.M. Bui (1997) and the report published by the Economic Policy Institute (2011) offer the viewpoint that government regulation in times of crisis are needed to ensure the integrity of the economy. A similar viewpoint could be adopted for biased software algorithms. Biased software algorithms foreshadow an upcoming crisis and government regulation and intervention could potentially help mitigate the damage or prevent it entirely.

Another point of the solution is to consider developing a public grade school class that teaches computer ethics and ethics in general. The cost of implementing these classes is likely to further increase the cost of public grade school education. Figure 4 shows a gradually increasing grade school education per student cost trendline and having to implement another class in grade school curriculum would likely increase costs further. The benefits of having ethically conscious citizens could be deemed priceless if it helps combat society damaging software.

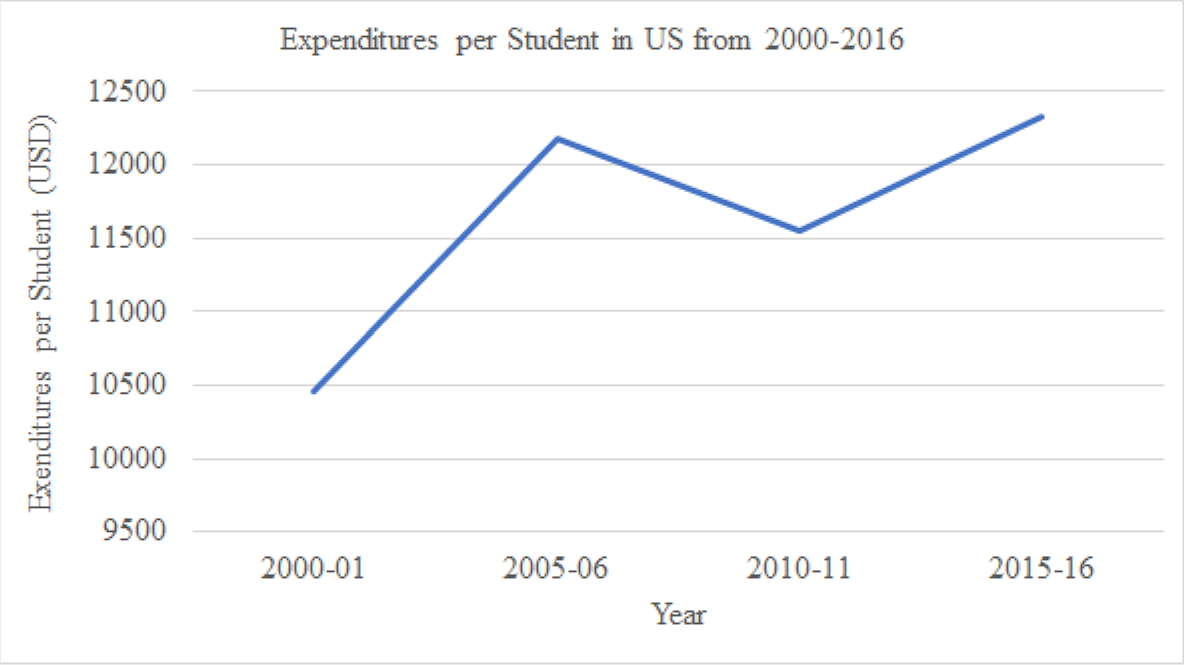

Figure 4: Cost of Education: Public Grade School Expenditures per student from 2000-2016 (Tan adapted from National Center for Education Services, 2019)

The issue of whether the government should regulate or let the population self-regulate more is an ethical dilemma as much as it is an economic one, however, the solution proposed in this paper is bound to be met with some resistance.

As the global market for software infrastructure continues to grow, the need to regulate software and computer algorithms to prevent social bias increases. There is currently little to no regulation of these algorithms and there is little awareness that the problem even exists. To remedy this, it is important to educate the general population about the fundamentals of computer ethics. This could come in the form of introducing a public grade school class dedicated specifically to this topic. Actions like these serve to increase technological literacy in the US population and therefore increase awareness of computer algorithms that may adversely affect lives. When an individual sees a socially discriminatory computer algorithm, they should be able to report this to a government regulatory agency dedicated specifically to monitoring software algorithms. Another vital part of the solution would come from duty ethics from the software development entities. These entities would outline all the unintended and intended uses of a software algorithm in patents. It would also be the duty of these entities to hire their own computer ethics testers instead of relying solely on their software developers to be ethical. These same software development entities should strive to be accountable for their work and the government should be able to enact fines to companies that develop unethical software and invade a person's wellbeing and privacy. Having a concrete ethics guideline for software developers to abide by mitigates the possibility of unintended uses of software algorithms to be exploited. These measures would be a step in the right direction in making computer algorithms more transparent.

WORKS CITED

AICPA. (2017). IRS issues reasonable internal-use software regulations for the research tax credit. AICPA. Retrieved from https://www.thetaxadviser.com/

Anderson, N & MacMillan, D (2019). Student tracking, secret scores: How college admissions offices rank prospects before they apply. The Washington Post. Retrieved from https://www.washingtonpost.com/

Asimov (1978). I do not fear computers. I fear the lack of them. News Advance. Retrieved from https://www.newsadvance.com/

Berman, E. & Bui, L. (1997). Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin. http://doi.org/10.2139/ssrn.45244

Conger K., Fausset, R., & Kovaleski, S. (2019). San Francisco Bans Facial Recognition Technology. The New York Times. Retrieved from https://www.nytimes.com

Computer Ethics Institute (1992). Ten Commandments of Computer Ethics. Computer Ethics Institute. Retrieved from http://computerethicsinstitute.org/

Dastin, J. (2018). Amazon scraps secret AI recruiting tool that showed bias against women. Reuters. Retrieved from https://www.reuters.com

Family Educational Rights and Privacy Act of 1974, 20 U.S.C. § 1232g (1974).

Finnegan, R. H. (1988). Literacy and Orality: Studies in the Technology of Communication. Oxford, UK, New York, NY, USA: Blackwell.

Hewlett-Packard Co. v. Bausch & Lomb Inc., 909 F.2d 1464, 1469, 15 USPQ2d 1525, 1528 (Fed. Cir. 1990)

IDC (n.d.). 2020 Technological Trends. IDC. Retrieved from https://www.idc.com/

ITEEA (n.d.). Technological Literacy Standards. ITEEA. Retrieved from https://www.iteea.org/

Indexology (2020). Sizzlers and Fizzlers: Research the all-time biggest gains and losses of the Dow and the S&P 500. Indexology. Retrieved from https://us.spindices.com/

Latour, Bruno. (2005). Reassembling the social: An introduction to actor-network-theory. Oxford: Oxford University Press.

Metz, C. & Singer, N. (2019). Many Facial-Recognition Systems Are Biased, Says U.S. Study. The New York Times. Retrieved from https://www.nytimes.com/

National Center for Education Statistics. (2019). How much money does the United States spend on public elementary and secondary schools. National Center for Education Statistics. Retrieved from https://nces.ed.gov/

Privacy Act of 1974, 5 U.S.C. Prelim. § 552a (2012 Ed. Supp. I, 2013)

Tan, P. (2020). Biggest Net Change in DJI 2000-2010 vs 2020 [Figure 1]. STS Research Paper: Computer Algorithms and Their Inherent Social Bias (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Tan, P. (2020). Modified Technological Handoff Model showing Computer Algorithm development [Figure 2]. STS Research Paper: Computer Algorithms and Their Inherent Social Bias (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Tan, P. (2020). Actor Network Theory: Actor Network Theory showing the proposed relationship between the U.S. Population, Government, and Publishing Entities [Figure 3]. STS Research Paper: Computer Algorithms and Their Inherent Social Bias (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Tan, P. (2020). Cost of Education: Public Grade School Expenditures per student from 2000-2016 [Figure 4]. STS Research Paper: Computer Algorithms and Their Inherent Social Bias (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

USAGov. (n.d.). A-Z Index of U.S. Government Departments and Agencies. USAGov. Retrieved from https://www.usa.gov/federal-agencies

Wessner, C. (2011). National Research Council (US) Committee on Comparative National Innovation Policies: Best Practice for the 21st Century. Building the 21st Century 2011. Panel III: ICT and Innovation: Growth Engine and Enabling Technologies. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK83233/

BIBLIOGRAPHY

Denise, M. L. (1962). Automation and Unemployment: A Management Viewpoint. The ANNALS of the American Academy of Political and Social Science, 340(1), 90–99. https://doi.org/10.1177/000271626234000112

Hillman, G.C. (1996) The Origins and Spread of Agriculture and Pastoralism in Eurasia, UCL Books, London, pp. 159–203; Sato, Y. (2003) "Origin of rice cultivation in the Yangtze River basin". In Y. Yasuda (ed.) The Origins of Pottery and Agriculture, Roli Books, New Delhi, p. 196

Newberry (n.d.). Technological Fix. Encyclopedia of Science, Technology, and Ethics. Retrieved from https://www.encyclopedia.com/science/

Sallomi, P. (n.d.). 2020 Technology Industry Trends. Deloitte. Retrieved from https://www2.deloitte.com

Van Ittersum, D. (2008). Computing attachments: engelbart's controversial writing technology. Computers & Composition, 25(2), 143-164.

Wang, J. (2018). What’s in Your Face? Discrimination in Facial Recognition Technology. Georgetown University. Retrieved from https://repository.library.georgetown.edu/