Stewardship in the "Age of Algorithms"

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OLD DOMINION
U N I V E R S I T Y

Outline

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- Background: The "Age of Algorithms"

- Algorithm trust dynamics

- Idealized documentation of systems in the Age of Algorithms

- The impossibility of traditional comprehensive archiving

- Documenting instead of archiving: Pragmatic approaches

- Thoughts on curation, population selection, and interpretation

- Conclusions/Final thoughts

Introduction

- There is no doubt that in today's world our lives revolve around computer algorithms
  - This environment creates concern for transparency and accountability
  - The author considers these terms over used and poorly defined
- We face a difficult problem of how do we document this new world
  - How do we archive a comprehensive record of present reality that could be used as an approximation in the future?
  - We want to capture the experiences these algorithms have on time and culture
- This paper addresses the value of stewardship for both high-stake and day-to-day algorithm interactions
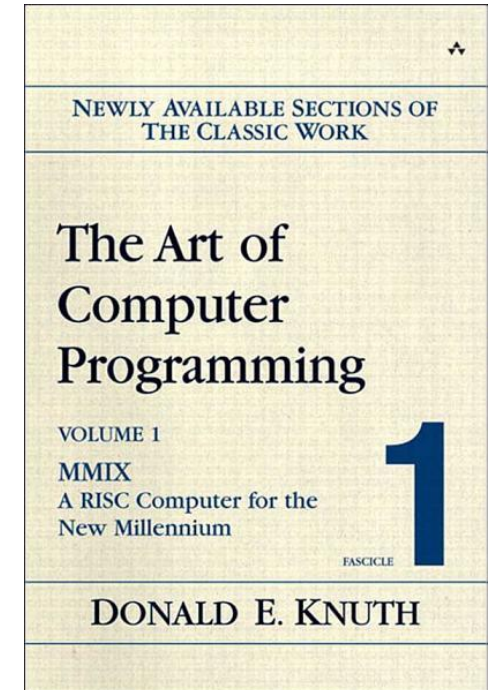 - Compromises have to be considered

Introduction (cont)

- Scope of this paper focuses on systems processing simple data producing informative outputs; opposed to robotic algorithms

- This paper focuses on a pragmatic and exploratory approach
  - Offers actions and ideas that can be implemented today

- We begin with characterizing what is means to be in the "Age of Algorithms"
  - Relates to challenges, perspectives, and accountability

- General and practical approaches differ from artifact-based
  - Requires collaboration between archivists, curators, researchers, and statistical discipline
  - Citizen archivist contributions

- The goal of this paper is to provide the groundwork for future discussions and provide practical ideas and approaches on this topic

Input → Algorithm process → Output
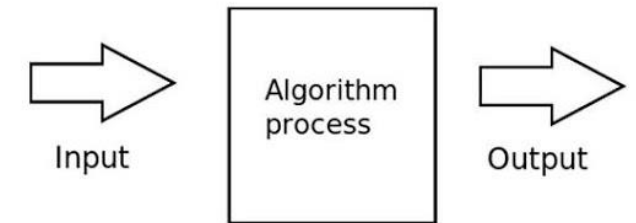
Background: The "Age of Algorithms"

- Algorithms, simply put, are methods for solving specific problems

- 20th Century characterization of algorithms are described as a finite number of computational procedures that end with a correct result

  - Predecessor disciplines, such as mathematics, moved toward computer science

- Donald Knuth, a great computer scientist, is considered most influential in adopting the algorithm concept

  - His work includes, "The Art of Computer Programming"

- 21st Century characterization of algorithms is much broader

  - Short-hand for complex socio-technical systems implemented by corporations and government

  - Decision algorithms cover personalization and recommendation engines related to consumer news, social media, and e-commerce

  - Modern services, such as speech and facial recognition, rely on multiple algorithms that are constantly and changing

NEWLY AVAILABLE SECTIONS OF
THE CLASSIC WORK

The Art of
Computer
Programming

VOLUME 1
MMIX
A RISC Computer for the
New Millennium
FASCICLE 1

DONALD E. KNUTH

Background: The "Age of Algorithms"

- Machine Learning (ML) takes a different approach where a system is trained and an algorithm is produced
  - These algorithms are successful for implementing strategies, recommendations, and image classification/recognition.

- These characteristics can be considered a threatening part of "Age of Algorithms"

- First problem is algorithms contain biases and limitations
  - This is not the fault of ML but the data used during training

- Second problem is the way algorithmic outputs are used
  - ML output is a prediction and must not be considered exact

- Third problem is these algorithms cannot stand alone
  - Path dependencies, proprietary code, unrecordable datastreams, un-reproducible behaviors

Background: The "Age of Algorithms"

- Content and context describes how the world has changed
  - Data is now presented to the viewer based on history and customizations
  - You may not receive all of the data you think

- Documenting these personalized systems and behaviors is important for consumers and scholars

- Popular examples of pervasive "Age of Algorithms"
  - Predictive policing and intelligence systems
  - Judicial sentencing recommendation systems
  - Student success and advising systems in colleges and universities
  - Recommendation algorithms in e-commerce
  - Medical diagnosis and treatment advisors
  - Algorithmic trading systems
  - Construction of personalized feeds on news, social media

Predictive policing and intelligence systems

- Using Artificial Intelligence(AI) to address criminal justice needs
  - Identifying individuals and their actions relating to criminal activity
  - DNA analysis
  - Gunshot detection
  - Crime forecasting

- National strategy for AI research and development
  - Detect patterns and anomalous behavior
  - Predict crowd behavior and crime patterns
  - Protect critical infrastructure
  - Uncover criminal networks

- By using AI, law enforcement will be better able to respond to incidents, prevent threats, stage interventions, and investigate criminal activity

- https://www.ncjrs.gov/pdffiles1/nij/252038.pdf

Judicial sentencing recommendation systems

- Algorithms are frequently used to predict a criminals likelihood of committing a crime.

- Correctional Offender Management Profiling for Alternative Sanctions(COMPAS) is a widely used tool
  - The software predicts the defendant's risk of committing a crime within 2 years based on 127 features of past history

- There is a debate over algorithmic fairness in the judicial setting
  - Studies show only two of these features can achieve the same results of all 137

- Unfortunately the interworking's of this algorithm are proprietary

- The COMPAS algorithm received a 65% accuracy rating from a study

- The accuracy of these algorithms will significantly affect the lives and well-being of criminals

- https://advances.sciencemag.org/content/4/1/eaao5580

Student success and advising systems in colleges and Universities

- Math undergraduate students design an algorithm to pair students with advisors
  - The university had a problem where students were being assigned to pre-major advisors but were interested in other topics
  - A group of students decided to modify an existing algorithm used for transportation problem
  - These types of algorithms are used for the distribution of material and have recently been adopted for student advising
  - Compatibility scores were generated from a survey
  - The algorithm is also adaptive to support additional input

- https://www.wm.edu/news/stories/2018/math-undergrads-deploy-algorithm-to-revamp-student-advising-system.php

Recommendation algorithms in e-commerce

- ## Recommendation algorithm for mobile E-commerce
  - Alibaba mobile e-commerce platform processes lots of data
  - Algorithms can analyze this rapid growth of data better than humans
  - The proposed algorithm can extract useful information features and make recommendations to the user
  - Studies show that this type of algorithm has a high success rate and can become very valuable to the e-commerce industry


- https://www.tandfonline.com/doi/abs/10.1080/1206212X.2019.1649346?journalCode=tjca20

Medical diagnosis and treatment advisors

- Early melanoma detection
  - Skin diseases are the fourth most frequent cause of disability in the world
  - Advancements in artificial intelligence are playing an important role in early detection
  - Recent neural network algorithms have demonstrated accuracy within family of dermatologists
  - In 2018 the European Society for Medical Oncology (ESMO) provided results of 95 algorithm accuracy over 86.6 percent human accuracy
  - In March 2020 the Journal of Investigative Dermatology published a study proving that AI could predict and classify 134 skin disorders

- https://www.altexsoft.com/blog/deep-learning-medical-diagnosis/
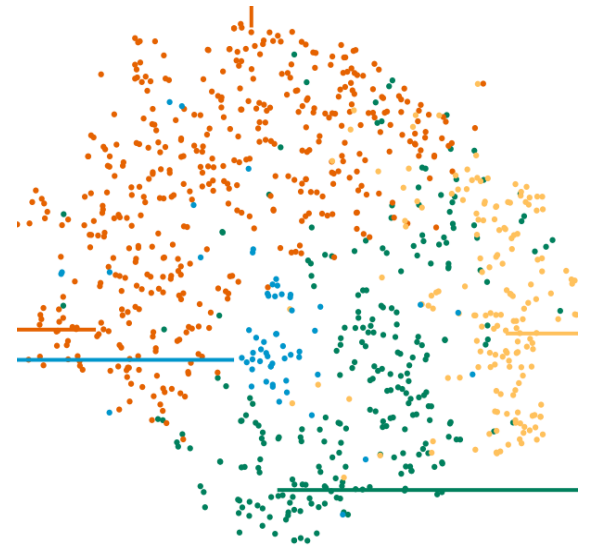
Algorithmic trading systems

- Picking the right algorithmic for trading software
  - Trust is involved when allowing an algorithm to trade your hard earned money
  - The algorithm must identify profitable opportunities and place trades frequently
  - Faster execution times and high accuracy are some benefits
  - Hedge funds and investment banks are using these algorithms during trades today and many of these are proprietary
- Characteristics of a good trading algorithm include:
  - Availability of market and company data, connectivity to market, latency detection, and interface customization
  - It is important to have the ability to back test algorithms on historical data
  - Integration with trading interfaces provides greater success

- https://www.investopedia.com/articles/active-trading/090815/picking-right-algorithmic-trading-software.asp

Construction of personalized feeds on news, social media

- How the Twitter Algorithm Works
  - The social algorithm is primarily based on personalization
  - Twitters ranking signals consists of:
    - Recency: How recent the tweet was published
    - Relevance: How often users engage with tweets of similar words
    - Engagement: How many retweets, clicks, favorite, etc
    - Media: Type of tweet media to include images, video, and polls

  - A series of complex calculations are computed based on these signals and what people liked in the past
  - Over time the algorithm has evolved to include more personalization for the user

  - https://blog.hootsuite.com/twitter-algorithm/

Algorithm trust dynamics

- Accountability directly relates to algorithmic-defined recommendations
  - Accountability analysis used to document the operation of these algorithms is limited
  - Most people do not take the entire algorithmic input into consideration
  - The perspective of stewardship is to document things "as is" or how they are, regardless of the explanation
- There are large systems that are difficult to analyze but are of interest due to dependencies
  - This includes ranking results and news feeds
- Transparency is important and cannot always be answered with software
  - Some systems are incomprehensible to humans
  - Rule-based systems are much easier to understand; however, they are more expensive and less flexible than modern ML systems

Algorithm trust dynamics (cont)

- What is important to transparency?
  - Training data and algorithm source code
  - Algorithmic output provides evidence of failures and biases
- Path dependencies for some systems require historical data of the algorithms operation
- A non-technical perspective of transparency is the intent of system designer
- Accountability and transparency inquiry is well established in the academic setting

Idealized documentation of systems in the Age of Algorithms

- Documenting the "Age of Algorithms" involves two methods
  - 1) Record each specific input and give the actual output at a given time
  - 2) Predict an algorithms output for a hypothetical set of input at any given time
- The first challenge is fully identifying the input
  - Secret or proprietary
  - Internal to system or path dependent
- The second challenge is replicating the system at a given time
  - Running a snapshot under environment control
  - Capturing outputs over time and changing properties to hypothesize system behavior
- The general problem here is we are unable to capture infinite performances from the algorithmic system at any given time
  - Instead the stewardship goal is to capture meaningful sense of the systematic behaviors for present and future.

The impossibility of traditional comprehensive archiving
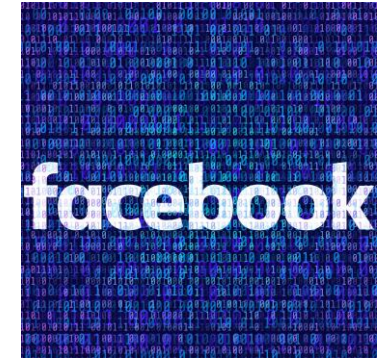
- Imagine Facebook providing all publicly available data to embrace stewardship of this data

- There are many problems and issues associated with this task
  - The petabytes of space required to store this data is astronomical
  - Most academic institutions will not have the economic means to support the require computational infrastructure
  - Privacy and legal concerns

- Two traditional methods (format migration, emulation)
  - Format migration works best with document-like objects and proprietary data types would not meet these standards
  - Emulation requires an entire software environment to be replicated to solve the technical complexity of this method
    - This method is better suited for interactive environments not connect to the Internet

Documenting instead of archiving: Pragmatic approaches

- The goal of stewardship is to capture the multiplicity of ways in which a system behaves under a range of conditions and users
  - Important Questions:
    - Who are the users?
    - How do we characterize them and how do we characterize the system?

- Archivists and digital preservationists provide stewardship through their experiences in many disciplines that document these behaviors

- There are two basic approaches for documenting observations of common system interactions

Documenting instead of archiving: Pragmatic approaches (cont)

- "Robotic Witnesses"
  - The first approach uses software robots to interact with the system and capture results
    - Robots are assigned demographics
    - Streams are managed and not predefined
    - Connectivity with the commercial surveillance ecosystem
  - Unfortunately bots can be detected by target systems and blocked
  - The robots must maintain synthetic identities and gather documentation
  - There seems to be limited knowledge on creating synthetic populations for archivists but there is a plethora of information regarding hacker or intelligence operation communities
  - Software robots are becoming prohibited for use with most systems
    - This technique could be in violation of Computer Fraud and Abuse Act (CFAA)
  - It is not clear if robots will be allowed in the university research setting

Documenting instead of archiving: Pragmatic approaches (cont)

- The second approach is to recruit actual humans to record the interactions of users
  - Actual humans do the recording of data
  - Which users and how many?
  - How long will the users stay engaged?
  - Authentic representation?
  - How much freedom do the users have with the system?

- System terms of use are not likely impacted as these users are legitimate humans
- The curators need special tools to follow and record these interactions
- Both of these approaches deviate from the traditional approaches of digital archiving
  - With these approaches comes complexities and uncertainty
  - Cost is also a factor

Thoughts on curation, population selection, and interpretation

- Many deep and complex problems
  - Recruitment of a population or build a population of robots
- The goal is to gain insight into targeted advertising and social networks
  - Social media, individual preferences, and choices play a factor
  - How these attributes are assigned also plays an important role with targeted advertising
- There are new efforts to measure audiences and characterize demographics
  - There is a gap between scholarly explorations and commercial practice for this effort
- Over the years mass advertising on cable tv has declined as firms have become focused on web-advertising
  - The entire framework has changed
- There are many combinations of audience attributes
  - Individuals are now characterized by age, income, gender, pet ownership, etc

Thoughts on curation, population selection, and interpretation (cont)

- Clustering is the idea that populations can be divided into clusters of similar characteristics but also represent a small subset of these combinations
  - Some attributes include income, interests, age, gender, family status, etc
  - This is a complex recipe of cost, capability, and precision tradeoffs
  - There are a vast number of different combinations

- The best personalization will likely be based primarily on historical data rather than demographics

- Even once clustering is refined, it will still need to be revisited periodically

- There are many unexplored questions on how to record and capture these interactions

- We must be cautious and humble regarding the data collected

Conclusions/Final thoughts

- Stewardship seeks to preserve an accurate sense of the present for the future
- There continues to be an issue where prior stewardship methods for digital archiving are not sufficient
  - We must understand how the "Age of Algorithms" will potentially impact consumers and society
  - There continues to be stewardship attempts to address the situation
- Brewster Kahle and David Rosenthal have provided insight and ideas to deviate from traditional methods
  - How the web has been changing over the past decade
- Twitter has been hospitable to researchers that desire to collect sample data
- These intractability problems need to be addressed using modern methods

Conclusions/Final thoughts

- Being successful in this new "Age of Algorithms" requires us to focus on experiences instead of artifacts
  - Pragmatic sense of recorded or documented personalized performances
- We must quickly determine who will create, capture, and curate during the "Age of Algorithms"
  - How we can get their work into the hands of organizations for storage
- Must consider how we will fund and support a new discipline and profession of Internet documentation
- Stewardship has never been perfect; however, the risk has increased in this new "Age of Algorithms"
  - There will be many challenges and shortfalls
  - These new roles will rely heavily on private collectors or freelancers
- The proposed solutions in this paper are presented to bring awareness and attention to this new era of archiving