

Trend Analysis of AI/ML Tools and Services in NASA

Introduction
This work aims to perform a benchmark study of AI/ML usage in NASA. The usage of Artificial Intelligence and Machine Learning (AI/ML) has recently seen an exponential increase, owing to high performance capabilities and their adoption of the technology. However, the use of AI/ML for Data Management and Computing for Data Analytics, Science and Engineering, the advancement of AI/ML has not yet fully appreciated and understood by the NASA's Human Machine Interaction (HMI) and its various disciplines. As such, it recommends testing parameters to increase the usage of AI/ML.

AI/ML Algorithms
Based on an extensive study of literature, we have identified AI/ML algorithms that have been predominantly used in the general science community. The algorithms are:
1. convolutional neural network
2. reinforcement learning
3. deep learning
4. neural network
5. self-learning
6. deep learning
7. Bayesian
8. Big data

Document Classification
For each of the documents, we tagged three sets of subject domain and AI/ML algorithm used. The tagging for subject domain was done based on the subject category available in the data itself. The subject category was manually tagged in the subject domain by domain experts.

Conclusion
Some of the general findings from the analysis are as follows:
1. AI/ML in NASA HMI has seen the same exponential growth as in the general science community.
2. Among the NASA HMI Divisions, the Earth Science Division is the best user of AI/ML usage.
3. The penetration of the various state-of-the-art machine learning techniques like deep learning, neural networks, etc., is leading to the NASA HMI.

Data Collection
To facilitate the analysis, we collected available journals, articles, and papers affiliated with NASA in our open research systems. We searched and identified one source of data: NASA's Technical Report Server (TRS) and NASA's Full-Text Search (FTS) provides access to NASA's available records of full-text articles, documents, images, and videos. It includes conference papers, journal articles, meeting papers, posters, research reports, images, movies, and technical videos. (1)

Results
The data was processed to extract the number of AI/ML-related publications for each year. The graph in Figure 2 shows the comparison of such publications published in NASA (NASA based) vs in the general science community. Even though the usage of AI/ML in NASA is on the rise, it is evident that the growth rate in AI/ML in NASA isn't comparable with that of the general science community.

Acknowledgement
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AI/ML trend in NASA vs General Science community

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General Science (SciPub)

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INTRODUCTION

This work aims to perform a landscape study of AI/ML usage in NASA.

The usage of Artificial Intelligence and Machine Learning (AI/ML) has recently seen an exponential increase, owing to high performance frameworks and rapid adoption of the technology. However, as the Strategy for Data Management and Computing for Groundbreaking Science report[1] finds, the advance of AI/ML has yet to be fully appreciated and understood by the NASA's Science Mission Directorate (SMD) and its science disciplines. As such, it recommends making investments to incentivize the use of AI/ML for achieving breakthroughs in science. It also finds that collaborations on such analysis could be facilitated by sharing results and lessons learned among the community.

To that end, an analysis of the current landscape is crucial.

AI/ML ALGORITHMS

Based on an extensive study of literature, we have identified AI/ML algorithms that have been predominantly used in the general science community.

The algorithms are:

convolutional neural network

reinforcement learning

deep bayesian

neural network

activelearning

deep learning

bayesian

big data

clustering

decision tree

dimensionality reduction

instance based

machine learning

regression

regularization

rule system

ensemble

It is important to note that the aforementioned algorithms aren't an exhaustive list of AI/ML algorithms; however, these are sufficient to cover the AI/ML usage in NASA.

DOCUMENT CLASSIFICATION

For each of the documents, we tagged them with a) science division and b) AI/ML algorithm used.

The tagging to a science division was done based on the ‘subject category’ metadata record available in the data itself. The ‘subject category’ was manually mapped to the science division by domain experts.

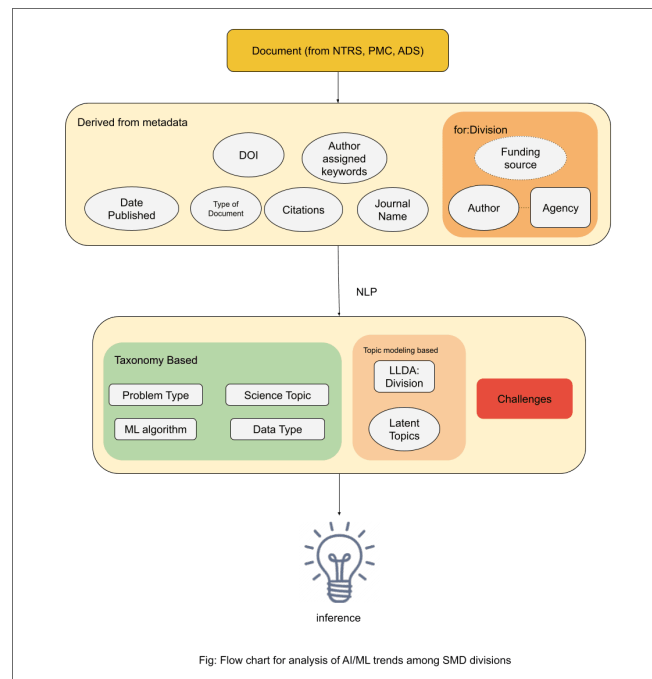


Figure 1

The tagging to an AI/ML algorithm was done by employing natural language processing to the text from the document title and abstract.

The workflow for analysis the trends of AI/ML in the NASA SMD is depicted in Figure 1.

CONCLUSION

Some of the prominent findings from the analysis are as follows:

AI/ML in NASA SMD hasn't seen the same exponential growth as in the general science community.

Among the NASA SMD Divisions, the Earth Science division is the forerunner of AI/ML usage.

The penetration of the newer, more advanced machine learning techniques like deep learning, neural networks, etc., is lacking in the NASA SMD.

DATA COLLECTION

To facilitate the analysis, we collected scientific journals, articles and papers affiliated with NASA from openly available sources.

We researched and identified two sources of data: NTRS (NASA Technical Report Server), and PMC (PubMed Central). NTRS provides access to NASA metadata records of full-text online documents, images, and videos. It includes conference papers, journal articles, meeting papers, patents, research reports, images, movies, and technical videos – scientific and technical information (STI) created or funded by NASA[2]. Similarly, PMC permanently preserves and provides public access to the peer-reviewed papers resulting from NASA-funded research[3]. We consolidated the list of documents, from the two sources, into a database. The database includes documents from the year 2000 AD to present.

RESULTS

The data was preprocessed to extract the number of AI/ML related submissions for each year. The graph in figure 2 shows the comparison of such submissions published in PubMed (NASA funded) vs in Arxiv (general science community). Even though the usage of AI/ML in NASA is on the rise, it is evident that the growth rate in AI/ML in NASA isn't comparable with that of the general science community.

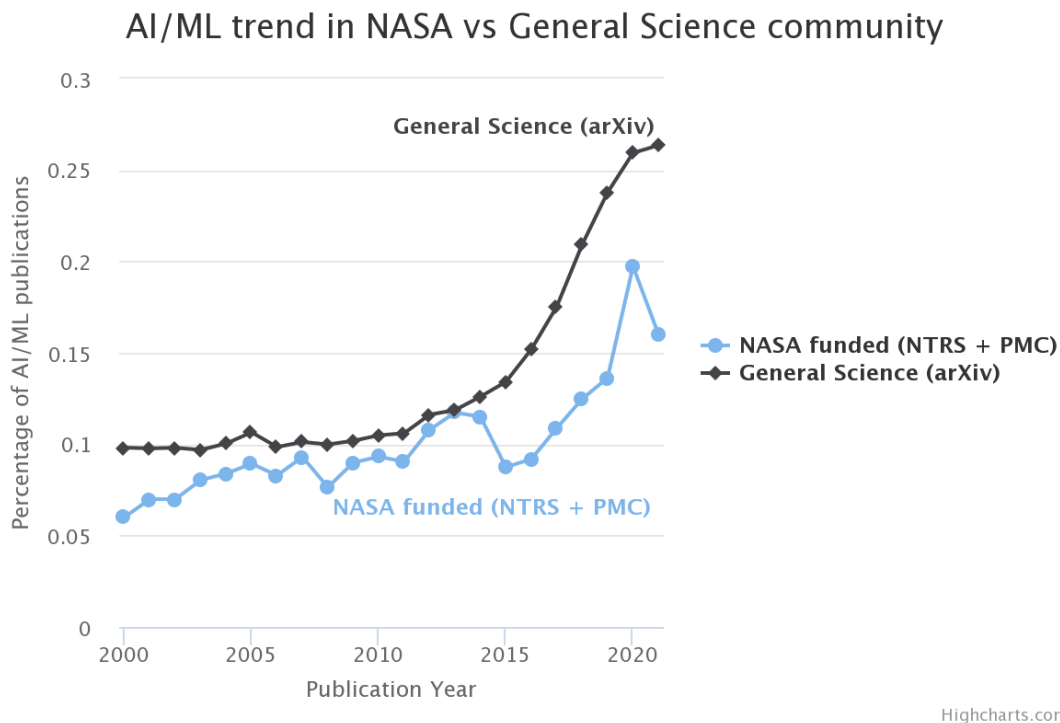


Figure 2

Furthermore, we looked at the distribution of those AI/ML related publications against the five SMD divisions, namely, Earth Science, Astrophysics, Planetary, Biophysical, Heliophysics, and the High End Computing for Science program. In figure 3, we see a huge discrepancy. The Earth Science division has the highest number of AI/ML submissions and the difference with the second highest contributing category 'Astrophysics' is staggering. However, it should be noted that these numbers have not been normalized based on the total number of submissions in each category.

AI/ML publication distribution across divisions

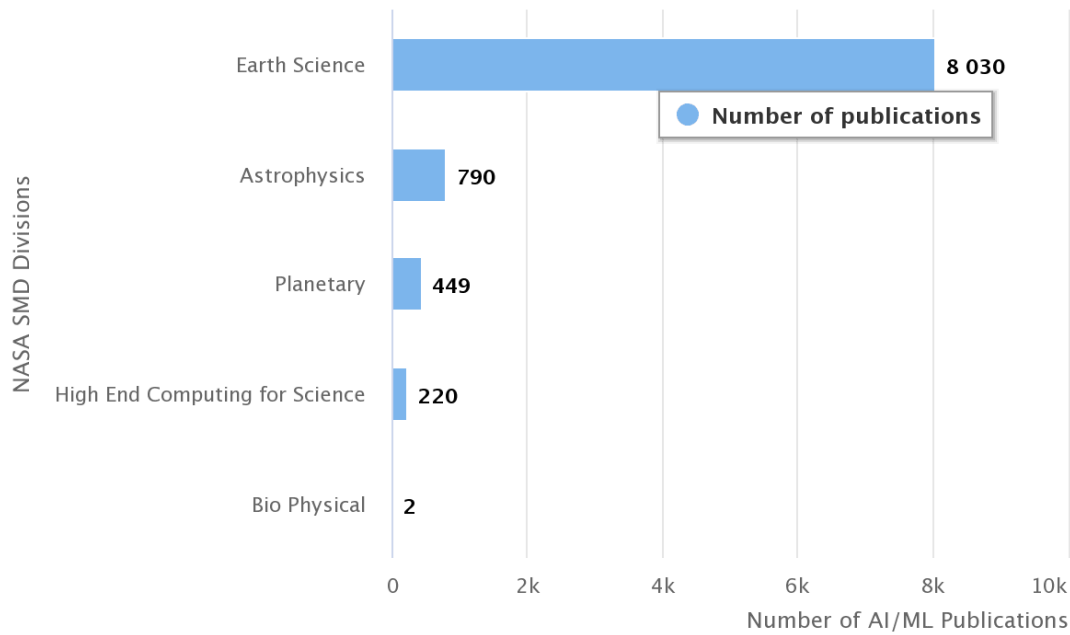


Figure 3

Further analysis on the taxonomy of algorithms shows that although deep learning - a class of neural networks that use multiple layers to capture highly non-linear dependencies in data - has been introduced and has been growing in the NASA SMD, the rate of increase is not on par with what is seen in the general science community. Figure 4 from [4] and figure 5 from NASA trends show this analysis.

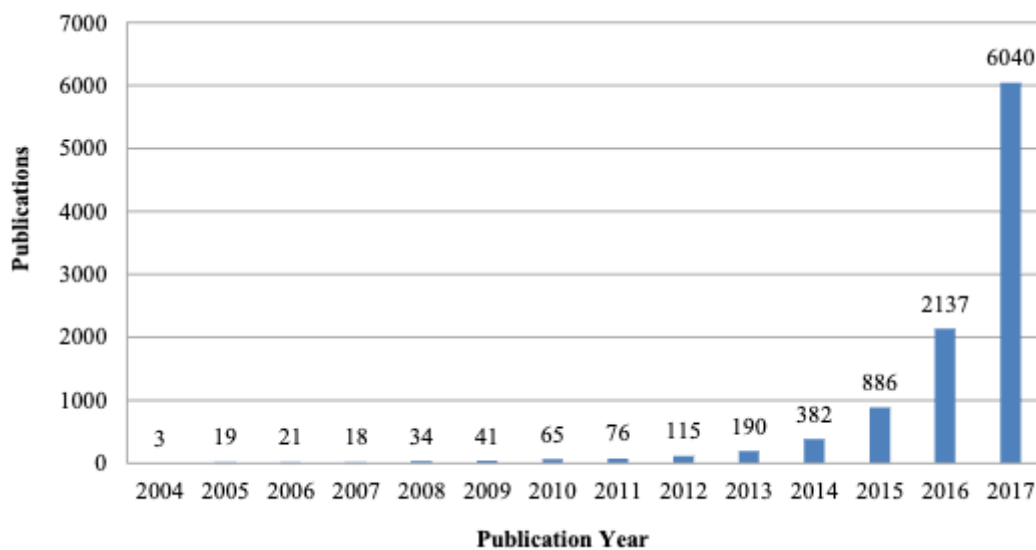


Figure 4^[4]

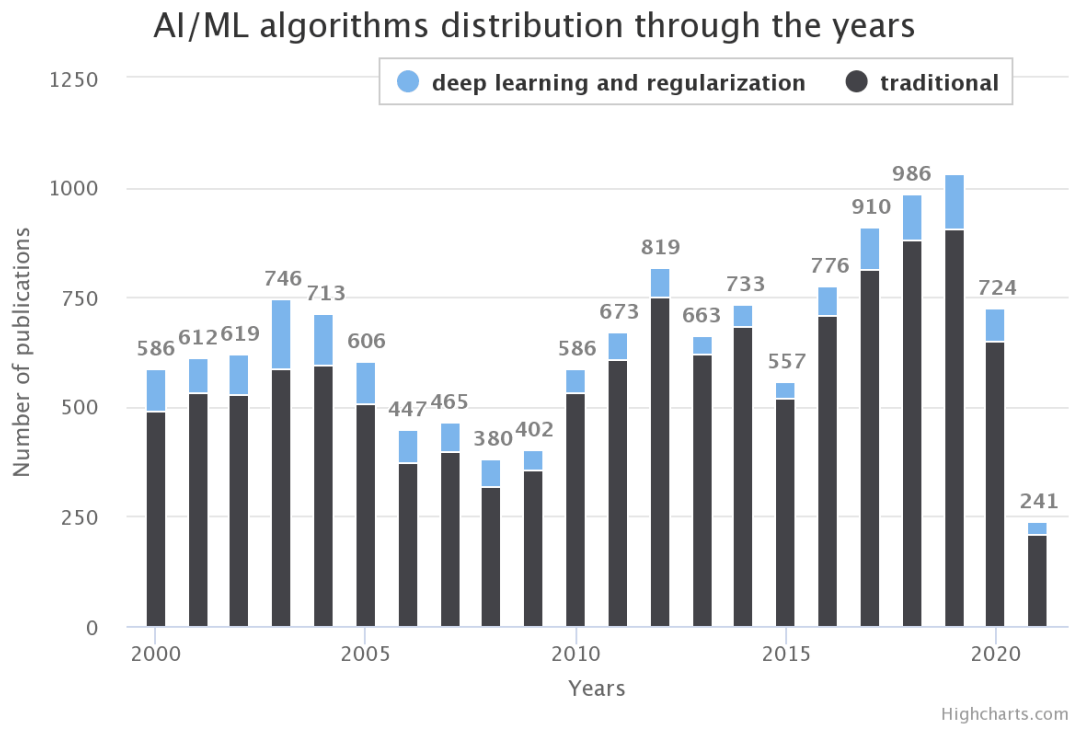


Figure 5

ACKNOWLEDGEMENT

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ABSTRACT

Usage of Machine Learning (ML) algorithms within NASA's Science Mission Directorates have been increasing over the years. This can be quantitatively observed in the upward trends of ML usage found by analyzing the publications and presentations (in affiliation with NASA) available through NASA Technical Reports Server (NTRS) and PubMed Central (PMC). Identifying the problem types and class of ML algorithms used to tackle them across the divisions can present opportunities for collaborations, interdisciplinary projects and knowledge transfer for sustainable partnerships. In this presentation, we will present the trend analysis of ML algorithms used in different SMD divisions based on the publications and presentations publicly available. We identify these trends by leveraging ML algorithms which are able to search through the publication texts semantically; which are also highly scalable. We will also present an analysis on the available open source tools and services in NASA leveraging AI/ML algorithms. This work will provide ample avenues for collaborative efforts across different disciplines based on the surfaced trends.

REFERENCES

- [1] Strategy for data management and computing for groundbreaking science. https://science.nasa.gov/science-pink/s3fs-public/atoms/files/SDMWG%20Strategy_Final.pdf (https://science.nasa.gov/science-pink/s3fs-public/atoms/files/SDMWG%20Strategy_Final.pdf)
- [2] NASA Technical Reports Server. <https://ntrs.nasa.gov/> (<https://ntrs.nasa.gov/>)
- [3] NASA in PubMed Central. <https://www.ncbi.nlm.nih.gov/pmc/funder/nasa/> (<https://www.ncbi.nlm.nih.gov/pmc/funder/nasa/>)
- [4] Deep Learning Research: Scientometric Assessment of Global Publications Output during 2004-17. <https://www.ijournalse.org/index.php/ESJ/article/view/124/71> (<https://www.ijournalse.org/index.php/ESJ/article/view/124/71>)