

A Quantitative Analysis on Machine Learning and Smart Farm with Bibliographic Data from 2013 to 2023

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Abstract

The convergence of machine learning and smart farm is becoming more and more important. The purpose of this research is to quantitatively analyze machine learning and smart farm with bibliographic data from 2013 to 2023. This study analyzed the 251 articles, filtered from the Web of Science, with regard to the article publication trend, the article citation trend, the top 10 research area, and the top 10 keywords representing the articles. The quantitative analysis results reveal the four points: First, the number of article publications in machine learning and smart farm continued growing from 2016. Second, the article citations in machine learning and smart farm drastically increased since 2018. Third, Computer Science, Engineering, Agriculture, Telecommunications, Chemistry, Environmental Sciences Ecology, Material Science, Instruments Instrumentation, Science Technology Other Topics, and Physics are top 10 research areas. Fourth, it is 'machine learning', 'smart farming', 'internet of things', 'precision agriculture', 'deep learning', 'agriculture', 'big data', 'machine', 'smart' and 'smart agriculture' that are the top 10 keywords composing authors' keywords in the articles in machine learning and smart farm from 2013 to 2023.

Keywords: *Machine Learning; Smart Farm; Artificial Intelligence; AI; Quantitative Analysis; Bibliographic Data*

1. Introduction

The objective of this research is to quantitatively analyze the convergence of machine learning and smart farm with bibliographic data from 2013 to 2023. The convergence of machine learning and smart farm is attracting much attention with the growing importance of both artificial intelligence [1, 2] and smart farm [3, 4]. Machine learning is a type of artificial intelligence [5] and machine learning is playing a more and more important role in operating successfully smart farm [6], which makes the applications of machine learning to smart farm become increasingly important [7]. Therefore, the quantitative analysis results from this study will be significantly helpful for enhancing relevant research in future.

This research tried to provide the answers to the four research questions (RQs) in regard to the convergence

of machine learning and smart farm from 2013 to 2023 as follows:

- (1) RQ 1: What are the main characteristics in article publications?
- (2) RQ 2: What are the main characteristics in in article citations?
- (3) RQ 3: What are the top 10 research areas?
- (4) RQ 4: What are the top 10 keywords?

2. Research Methods

This research analyzed the 251 articles from the Web of Science. It is a widely used database that is globally utilized for quantitative analyses with bibliographic data [8, 9]. The 251 articles have been filtered from the advanced search which were based on the integration of related key words such as 'machine learning' with 'smart farm', 'smart farms', or 'smart farming'. The timespan for the advanced search was from 2013 to 2023.

This research analyzed the 251 data related to the four dimensions, such as annual article publication trend, annual article citation trend, top 10 research areas, and top 10 keywords. The bibliometrix (biblioshiny) [10] — a package of R program [11] — was utilized to carry out the keywords-related analyses which were the word cloud and the top 10 keywords in machine learning and smart farm from 2013 to 2023.

3. Result

3.1. Annual Article Publication Trend

Figure 1 indicates the annual article publication trend in machine learning and smart farm from 2013 to 2023. Two characteristics have been found out as follow: First, the article publications began in 2016 and 2 articles were published in it. Second, they continued growing since 2016. In 2018, the number of article publications increased to 9. The article publications amounted to 39 in 2020. The number of article publications increased to 57 and 78, respectively, in 2022 and 2023.

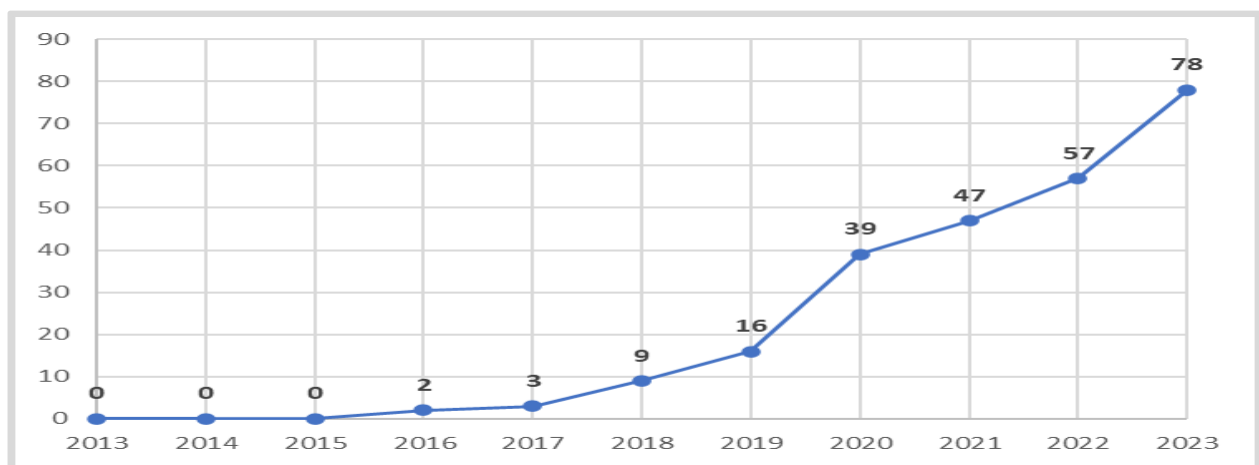


Figure 1. Annual article publication trend in machine learning and smart farm

3.2. Annual Article Citation Trend

Figure 2 shows the annual article citation trend in machine learning and smart farm from 2013 to 2023. The article citations started in 2018 and the number of article citations were 4 in it. They have increased drastically until 2023. They amounted to 22 in 2019 but it increased to 580 in 2021. The number of article citations amounted to 1,104 and 1,632, respectively, in 2022 and 2023.

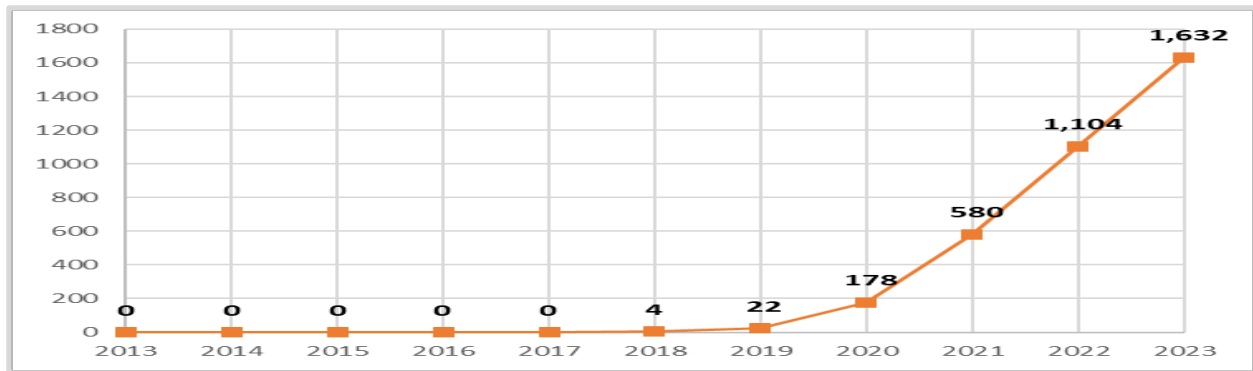


Figure 2. Annual article citation trend in machine learning and smart farm

3.3. Top 10 Research Areas

Figure 3 visualizes the top 10 research areas in the 251 articles published in machine learning and smart farm from 2013 to 2023. Computer Science was ranked as the top 1 with 129 article publications (51.4%). Engineering was ranked as the top 2 with 88 article publications (35.1%). Agriculture was ranked as the top 3 with 53 article publications (21.1%) and Telecommunications was ranked as the top 4 with 47 article publications (18.7%). Chemistry was ranked as the top 5 with 18 article publications (7.2%), Environmental Sciences Ecology as the top 6 with 16 article publications (6.4%), and Material Sciences as the top 7 with 14 article publications (5.6%). Both Science Technology Other Topics and Instruments Instrumentation were ranked as the top 8 with 12 article publications (4.8%). Physics was ranked as the top 10 with 11 article publications (4.4%).

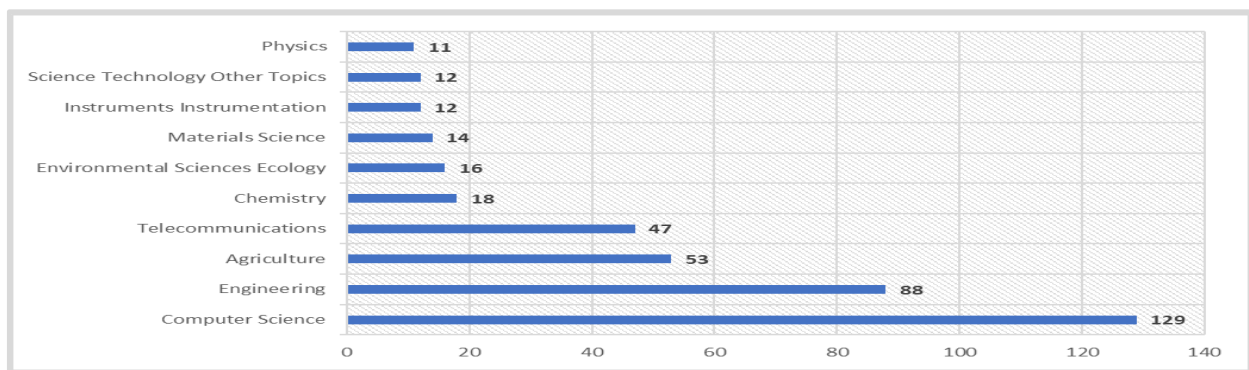


Figure 3. Top 10 research areas in article publications in machine learning and smart farm

3.4. Top 10 keywords

Figure 4 shows the word cloud of authors' keywords. 'Machine Learning' was ranked as the top 1 with the frequency of 115. 'Smart farming' and 'internet of things' were ranked as the top 2 and 3, respectively, with the frequency of 106 and 64. 'Precision agriculture' and 'deep learning' were ranked as the top 4 and 5, respectively, with the frequency of 34 and 27. 'Agriculture' and 'big data' were ranked in the top 6 and the top 7 respectively, with the frequency of 25 and 18. 'Machine', 'smart' and 'smart agriculture' were co-ranked as the top 8 with the same frequency of 17.



Figure 4. Word cloud of authors' keywords

4. Conclusion

The research objective of this study is to quantitatively analyze machine learning and smart farm from 2013 to 2023. The analysis results present findings which can contribute to deepening the understanding about the annual article publication trend, annual article citations trend, top 10 research areas, and top 10 keywords in machine learning and smart farm from 2013 to 2023, concerning the four RQs as follows:

First, related to the RQ1, the article publications in machine learning and smart farm were found out to continue growing from 2016. From 2013 to 2015, no article was published, as seen in Figure 1. However, in 2016, 2 articles were published. The number of article publications increased to 16 and 78, respectively, in 2019 and 2023 with a constant growth.

Second, concerning the RQ 2, the number of article citations in machine learning and smart farm was revealed to drastically increase since 2018. From 2013 to 2017, no article citations happened, as seen in Figure 2. The number of article citations was 4 in 2018 but it increased to 178 in 2020. The number of article citations in 2021 and 2022 amounted to 580 and 1,104, respectively, in 2021 and 2022. It increased to 1,632 in 2023.

Third, regarding the RQ 3, the 251 articles in machine learning and smart farm were found out to be distributed in diverse research areas as seen in Figure 3. In more details, Computer Science, Engineering,

Agriculture, Telecommunications, Chemistry, Environmental Sciences Ecology, Material Science, Instruments Instrumentation, Science Technology Other Topics, and Physics were revealed to be the top 10 research areas in the articles in machine learning and smart farm from 2013 to 2023.

Fourth, related to the RQ 4, it is ‘machine learning’, ‘smart farming’, ‘internet of things’, ‘precision agriculture’, ‘deep learning’, ‘agriculture’, ‘big data’, ‘machine’, ‘smart’ and ‘smart agriculture’ that were found out to be the top 10 keywords composing authors’ keywords in the articles in machine learning and smart farm from 2013 to 2023.

5. Limitations and Suggestions for Future Research

Despite the findings above-mentioned, there are several limitations in this study, which need to be overcome in future relevant research. First, this study did not cover the change of the top 10 research areas or the top 10 keywords over time. Future research, which will cover it, is expected to provide more in-depth analysis results. Second, this study did not cover the application of machine learning and smart farm to various industries. It is more desirable for future studies to cover it. Third, this study used only one data source but it will be better for future studies to use various data sources with more recent timespan.

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