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A Bibliometric Survey of Fashion Analysis using Artificial Intelligence

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A Bibliometric Survey of Fashion Analysis using Artificial Intelligence

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Abstract In the 21st century, clothing fashion has become an inevitable part of every individual human as it is considered a way to express their personality to the outside world. Currently the traditional fashion business models are experiencing a paradigm shift from being an experience-based business strategy implementation to a data driven intelligent business improvisation. Artificial Intelligence is acting as a catalyst to achieve the infusion of data intelligence into the fashion industry which aims at fostering all the business brackets such as supply chain management, trend analysis, fashion recommendation, sales forecasting, digitized shopping experience etc. The field of "Fashion AI" is still under research progress because the fashion data is a multifaceted entity which is available in any of the forms like an image, video, text and numerical values. Therefore, it becomes a challenging research arena. There is a paucity of a common study which can provide a bird's eye view about the research efforts and directions. In this paper, the authors represent a bibliometric survey of the AI based fashion analysis domain based on the Scopus database. The study was conducted by retrieving 581 Scopus research papers published from 1975-2020 and analysed to find out critical insights such as publication volume, co-authorship networks, citation analysis, and demographic research distribution. The study revealed that significant contribution is made via concept propositions in conferences and some papers published in the journal. However, there is a scope of lots of research work in the direction of improving fashion industry with AI techniques.

Keywords: Fashion Analysis, Artificial Intelligence, Deep learning, Image analysis.

1.   Introduction

Apart from being a day to day necessity, fashion clothing has started serving a greater purpose to showcase individuality and self-confidence. Fashion is a field which is an amalgamation of constant change, creativity, and inclusion of latest techniques to keep churning the "newness" wheel [1]. To achieve this, a lot of manual or semi-automated inference is taken from multiple aspects of the fashion business such as amount of sales, audience catered, financial backgrounds, raw material used, designs or trends that got appreciated etc[2]. The advent of technology has altered the operating pattern of almost all the essential activities and online shopping is one such domain where it is creating massive disruption. To provide an actual and satisfying online shopping experience, personalized attention to each customer is a mandate which is a critical challenge as well to the fashion industry [3]. AI based data analytics is proving a promising hand holding for the fashion industry which can provide automated intelligence to many crucial processes of this billion-dollar business [4]. Techniques like computer vision, natural language processing, clustering algorithms, generative adversarial networks, classification, and regression methods are at the forefront. The application of computer vision is mainly done for fashion image analysis to detect objects and relevant image retrieval for recommendations. Many researchers have represented their ideas for effective feature extraction and accurate attribute/object detection AI based models for daily fashion related images [5][6][7]. Natural language processing techniques are used to understand the sentiment towards a particular trend [8], implementing multimodal recommendation systems, and developing the conversational chatbots for customer assistance [9]. These techniques are highly effective in understanding the reviews of the customers towards the products that they are buying which can form a base for future business strategies. Generative adversarial networks are employed to accomplish the task of "AI based fashion designing" by automating the generation of fashion images, videos, and text based on the given input seed values [10][11]. The classification algorithms are mainly utilized in automating the task of trend forecasting. It mainly includes identifying the apparel type, fabric used and applied design styles which makes

it easier to recognize an accurate trend pattern from the huge amount of data available. AI enabled robots can be installed in the product manufacturing setup for improved manufacturing output. For selling the fashion products, pattern recognition and prediction techniques can be employed which will help to enhance the marketing strategies [12]. But at the same time, the privacy of customer data, their personal choices and billing info must be taken care of. [13][14] AI can be applied for multiple specific activities to enhance the overall working of the fashion industry and to maximize the financial gains as well. Figure 1 shows an overview of the application domains of AI in the field of Fashion.

Figure 1 Applications of artificial intelligence in fashion industry

2.   Bibliometric Analysis of Artificial Intelligence for Fashion Analysis

In this section initially, information of recent related work in the area of fashion using AI is provided. Then, detailed bibliometric analysis of available publications is represented and discussed. For bibliometric analysis, documents and related data retrieved from Scopus database-"Source: http://www.scopus.com (Access date: 23-10-2020)".

2.1.   Related Work

In recent years, many researchers tried to explore and provide solutions for different tasks in fashion using the concepts of artificial intelligence which are mentioned further.

        Authors contributed for fashion recommendation in [15], [16], [17], [18], [19], fashion forecasting/ trend analysis in [20], [21], [22], [24], fashion image object detection/classification in [25], [26], [27], [28], [29], Fashion Image Generation/Manipulation in [30], [31], [32], visual search in [33], [34]. In Table 1, brief information from some of the recently published papers on fashion using AI are provided. In Figure 2, research contribution for various tasks in fashion are represented based on the approximate count of publications available on different tasks related to fashion. It illustrates that many researchers worked for fashion recommendation task as compared to other fashion tasks.

Table 1 Recent literature accomplishing different fashion related tasks

Sr.No	Paper reference	Task achieved	Input entity	AI Technique used	Probable applications	Advantages	Challenges/ limitations

1.	[15]	Fashion compatibility modeling	Images	Generative Adversarial Network	Fashion Recommendation	Provides compatibility preference for the item-item and item-template perspectives	Able to measures the compatibility between two fashion items only
2	[16]	Outfit recommendation	Image and Text	Attention-based fusion methods	Fashion/outfit Recommendation	Able to learn relevant correlations between fine-grained fashion attributes	not yet provide a strong preference for fine-grained item representations over coarse-grained representations
3	[17]	Explainable Outfit Recommendation	Image and Text	Convolutional neural network, Gated recurrent neural network with a cross-modality	Fashion/outfit Recommendation, Comment generation	Recommendations available with explanations	Generate short comments, maximum comments are positive and rarely negative comments provided
4	[20]	Fashion analysis and forecasting	Images	Soft computing with unsupervised learning, Predictive models	Fashion forecasting, Business decision making	Able to deal with value data	Dealing with social data which is unstructured
5	[21]	Fashion trend forecasting	Image	Knowledge EnhancedRecurrent Network model	To generate professional fashion trend report	Able to capture the complex patterns in the time-series data	more user information need to consider
6	[22]	Fashion style trend analysis	Image	RetinaNet	Decision-making	Very useful for professionals	Part of study dependent on experts feedback

| 7	[27]	Fashion image classification	Image	Classification and symmetry-based learning techniques	Garment Categorization	Able to handles unbalanced data	Large amount of labelled data required
8	[28]	Text mining for fashion analysis	Fashion blogdata-text	Rule-based classification	Supply chains decision making	Utilization of social media data useful for enables structural and targeted exploitation	Need to deal with unstructured and ambiguous data
9	[30]	Clothing segments synthesis	Images	Rule-based approach and CNN	virtual trial	Customers are able to check suitable clothing style virtually	Need to improve for natural look
10	[33]	Visual search	Images	Deep semantic granularity metric learning, Multitask-CNN, Soft-binomial deviance loss	Useful for clothing e-commerce	Simple in terms of computations	To achieve optimal results cropped images required
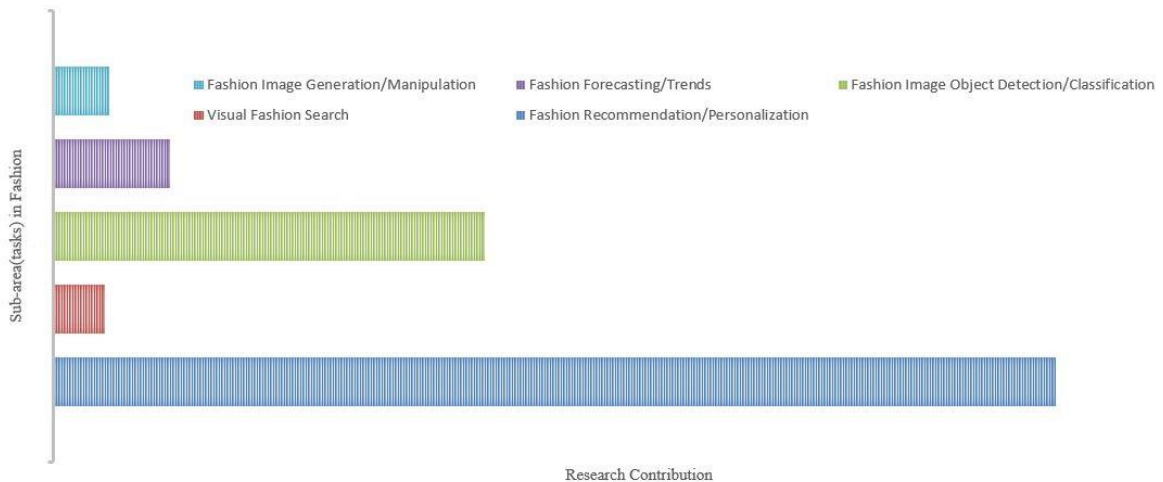
Figure 2 Research contribution for different tasks of fashion

2.2. Bibliometric Analysis

2.2.1.   Analysis of Keywords

Table 2 List of Keywords used for Document Retrieval

Keyword type	Keywords
Primary Keyword 1	"artificial intelligence"
Secondary Keyword (OR)	"deep learning", " machine learning", "supervised learning", "unsupervised learning", "neural networks", "clustering", "classification"
Primary Keyword 2 (AND)	" fashion recommendation system", "fashion forecasting", "Fashion trend"
Secondary Keyword (OR)	fashion and (ecommerce or style or apparel or clothing or outfit)

Query used to retrieve documents for the analysis from Scopus is ("artificial intelligence" OR ((deep OR machine OR supervised OR unsupervised) AND learning) OR "neural networks" OR clustering OR classification) AND (" fashion recommendation system" OR "fashion forecasting" OR "Fashion trend" OR (fashion AND (ecommerce OR style OR apparel OR clothing OR outfit))) AND NOT (symposium OR conference)

2.2.2.   Initial Search Results

Scopus database is used for retrieving documents for the analysis provided in this paper. On the above specified query search, total 581 research publications retrieved. Main publications considered here are written in English language i.e. 543. Different languages used for writing articles on fashion using artificial intelligence are specified in Table 3.

Table 3 Language Details of Publications on Fashion using Artificial Intelligence

Publication Language	No. of Publications
Chinese	17
Czech	1
English	543
English; Czech	1
English; Portuguese	1
German	1
Japanese	2
Korean	4
Russian	2
Slovenian	1
Turkish	2

In this survey, all the types of documents are considered i.e. articles published in journals and conference proceedings, book chapters, etc. detailed information is provided in the Table 4.

Table 4 Different type of Publications on Fashion using Artificial Intelligence

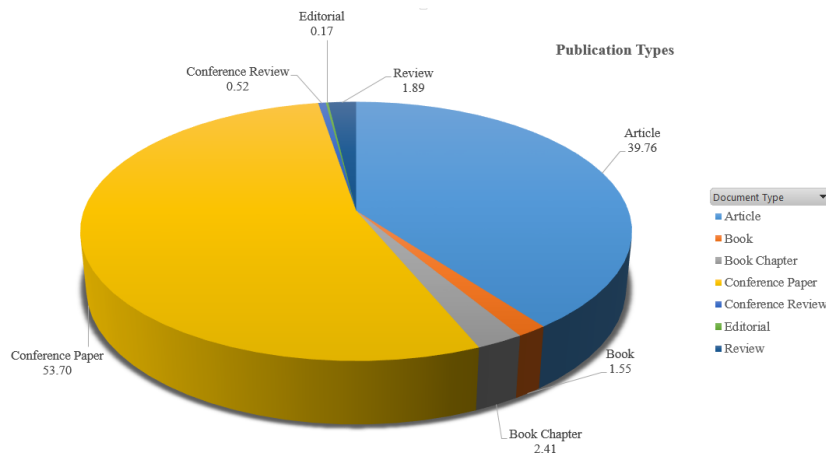| Publication Type	No. of Publications
Article	231
Book	9
Book Chapter	14
Conference Paper	312
Conference Review	3
Editorial	1
Review	11

Figure 3 Analysis of Publication Types

Based on the details retrieved related to type of publication, it is found that maximum contribution on the topic of fashion using artificial intelligence is done through conference papers and journal articles i.e. 53.70% and 39. 76% respectively. Whereas, some information is published through review articles, books and book chapters. Negligible publications are done through Conference review and editorial.

2.2.3.   Exploratory Data Highlights

In this subsection, analysis of publication count over years is done. Here, the number of publications related data from 1975-2020 is taken into consideration. It is represented in the form of graph in figure 4 where it is found that many researchers turned their focus towards fashion analysis in the last five years i.e. after 2015. Highest count detected in 2019 i.e. 136. However, before 2015 only a few researchers contributed to this field.
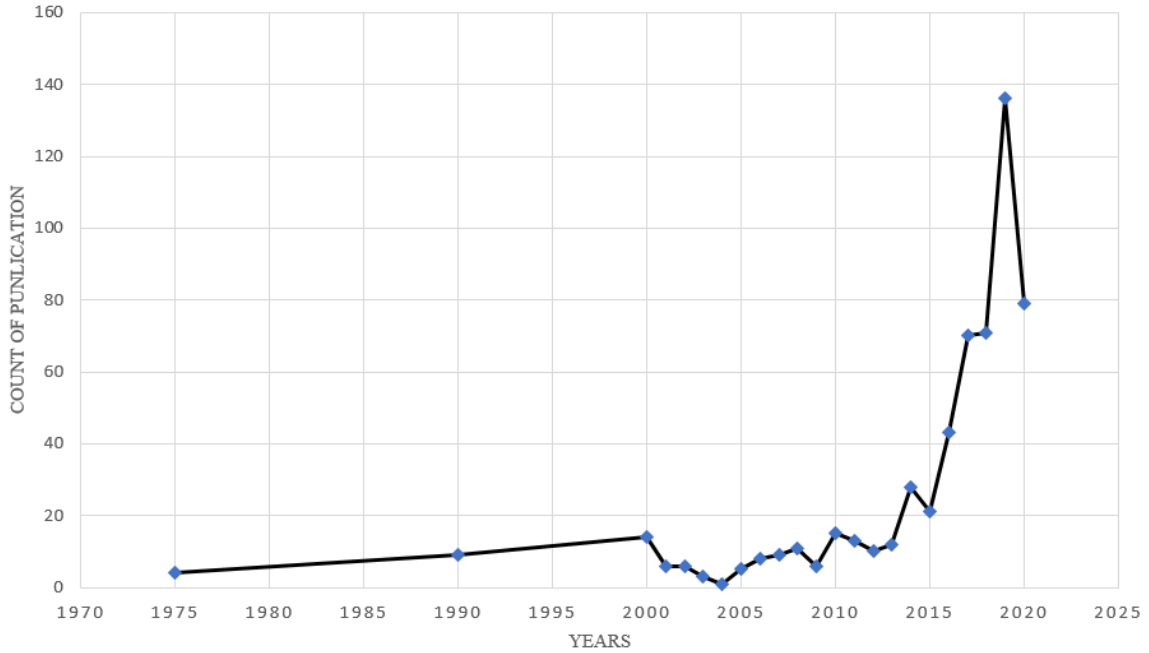
Figure 4 Yearly Analysis of Publication Count

2.2.4.   Geographical Analysis

Geographical analysis is used to analyse the geographical regional locations (country/territory) where research in the field of fashion using artificial intelligence is carried out. In the following Figure, research publication frequency is illustrated using world map and color intensities. Top most count found at China i.e.143 followed by United States i.e. 113 and India- 42. For more details, Table 5 is also provided to get the exact count for each country.

Figure 5 Geographical Analysis of Publication Count

Table 5 Geographical Count of Publications on Fashion using Artificial Intelligence

Country/Territory	Publication Count	Country/Territory	Publication Count
China	143	Austria	4
United States	113	Malaysia	4
India	42	Norway	4
United Kingdom	37	Russian Federation	4
Hong Kong	36	Viet Nam	4
South Korea	27	Bangladesh	3
Japan	26	Belgium	3
Taiwan	20	Iran	3
Singapore	19	Israel	3
Germany	18	Morocco	3
Australia	15	Poland	3
Canada	12	Sri Lanka	3
Italy	12	United Arab Emirates	3
France	11	Czech Republic	2
Sweden	10	Denmark	2
Switzerland	9	Kazakhstan	2
Finland	8	Slovenia	2
Spain	8	Egypt	1
Turkey	8	Iraq	1
Brazil	7	Ireland	1
Indonesia	7	Kuwait	1
Romania	7	Mexico	1
Netherlands	6	Nepal	1
Pakistan	6	Nigeria	1
Portugal	6	Philippines	1
Greece	5	Slovakia	1
Thailand	5	Ukraine	1

2.2.5.　Subject Area Analysis

Generally, researchers from different fields try to solve the problems in a specific field from their perspective. Therefore in this subsection, subject area is taken into consideration as the basis for analysis. In Figure 6, publication counts in different fields represented. It is found that many researchers in the Computer Science field have contributed as compared to other fields. Major contribution is given by researchers from Computer Science and Engineering fields i.e. 52.9 % of overall research.
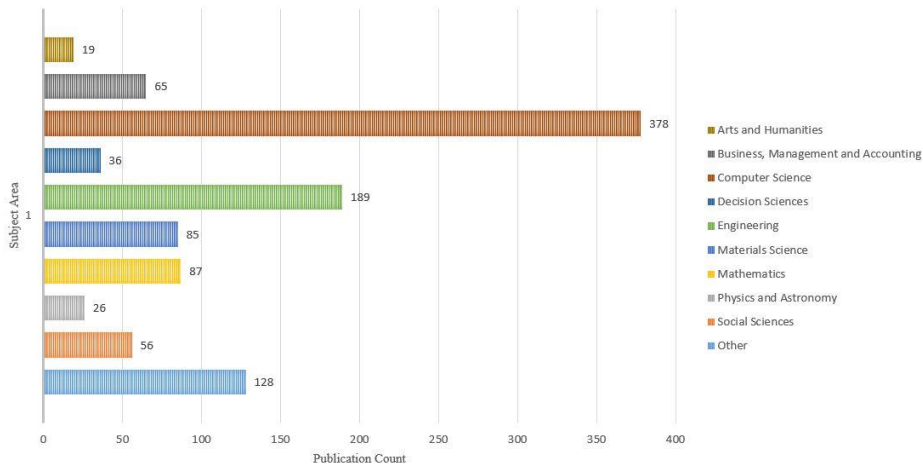
Figure 6 Subject Area Analysis of Publication Count

2.2.6.   Network Analysis

Network analysis is carried out through network visualization using software tools like VOSviewer and Gephi. In network visualization graphs, nodes and edges are used to represent relationships or connections between different considered attributes.

In Figure 7, network visualization is represented for all keywords and source titles. Here circles are used to represent nodes i.e. keywords from source titles. 5 is the threshold value used for minimum no. of keyword occurrence. Artificial intelligence and deep learning are detected as dominant keywords. Total 7 clusters found in the visualization represented using various colors. Total 201 items connected with each other through 3951 links.
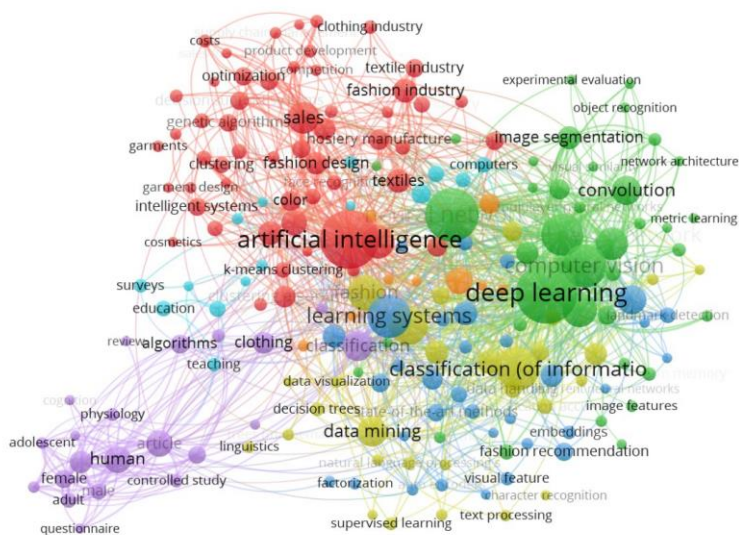

Figure 7 Keywords and Source Titles -Network Visualization

Visualization provided in Figure 8 represents a network map of publication title and citations. Total nodes 1229 are representing publication titles which is a collaborative work of researchers. It is having 951

connections i.e. directed edges where the incoming arrow represents the citation for that paper. Green, pink, orange and blue colors representing highest cited publications. Fruchterman Reingold Layout from Gephi is used to generate this visualization.
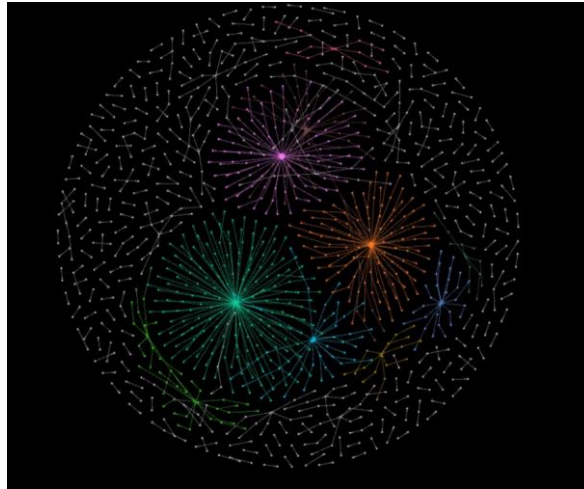

Figure 8 Publication Title and Citations- Network Visualization

To represent the collaborative work network visualization provided for author and co-authors in Figure 9. Parameter value for minimum number of documents of the author is set to 3. Visualization is having a total 50 nodes divided into 8 different clusters. Total links showing collaboration are 102.
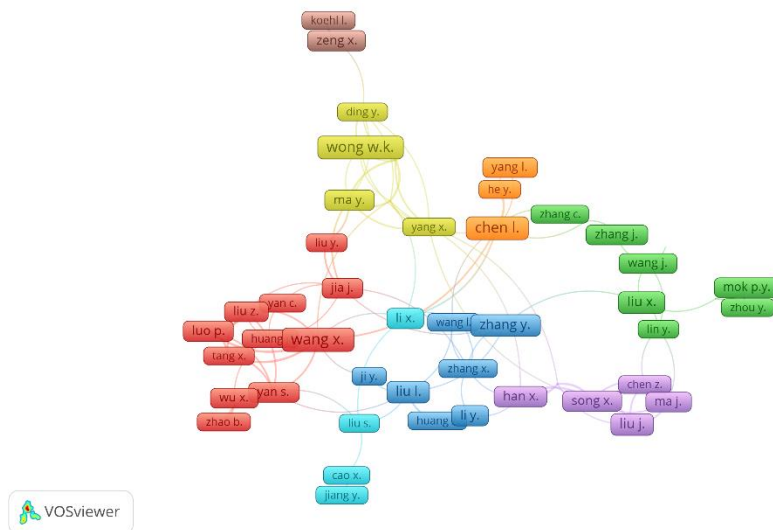

Figure 9 Author and Co-authors- Network Visualization

2.2.7. Statistical Analysis

In this section statistical analysis is carried out based on the different attributes like affiliation, source title, authors, citations and funding bodies.

2.2.8. Affiliation based Statistical Analysis

Affiliation based statistical analysis shows that "Hong Kong Polytechnic University" and "Donghua University" contributed with highest number of publications in the area of fashion and utilized concepts in artificial intelligence. In Figure 10, universities published more than equal to 5 publications in this area are represented. Total 586 universities have published research work in this field. 3-4 number of publications is average value publication value for different universities.
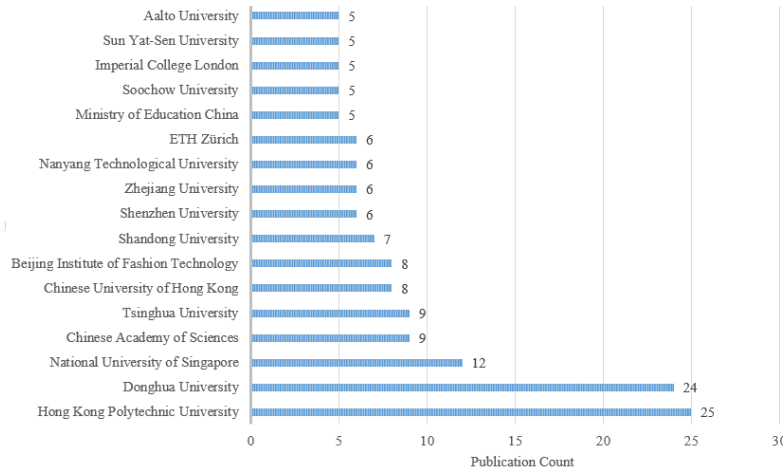

Figure 10 Analysis of Affiliations and Publication Count

2.2.9. Source Titles based Statistical Analysis

In this subsection, analysis is carried out for publication count with respect to sources. It is found that the source title "Lecture notes in computer science" published the highest no of papers i.e. 41. In Figure 11, sources titles with a number of published papers greater than or equal to 5 in the field of fashion using artificial intelligence are represented. This analysis will be very useful for new researchers in this field in order to publish their new work in a suitable source.
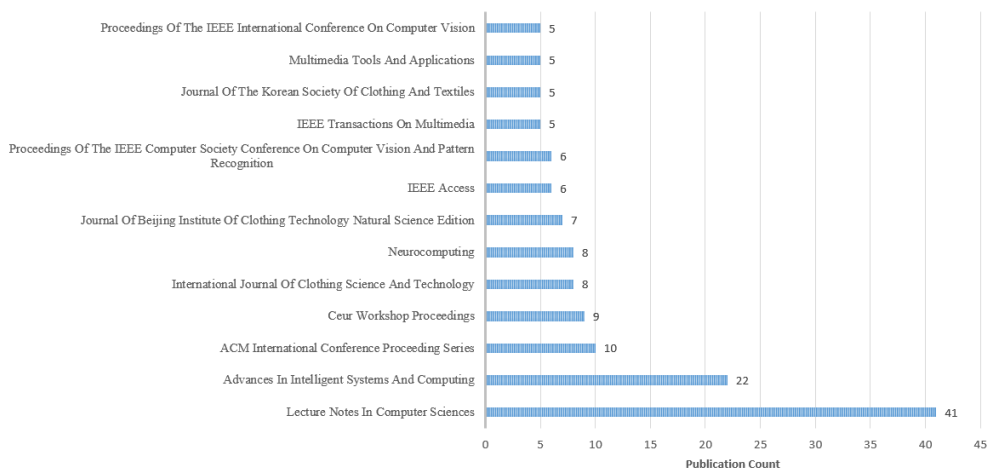

Figure 11 Analysis of Source Titles and Publication Count

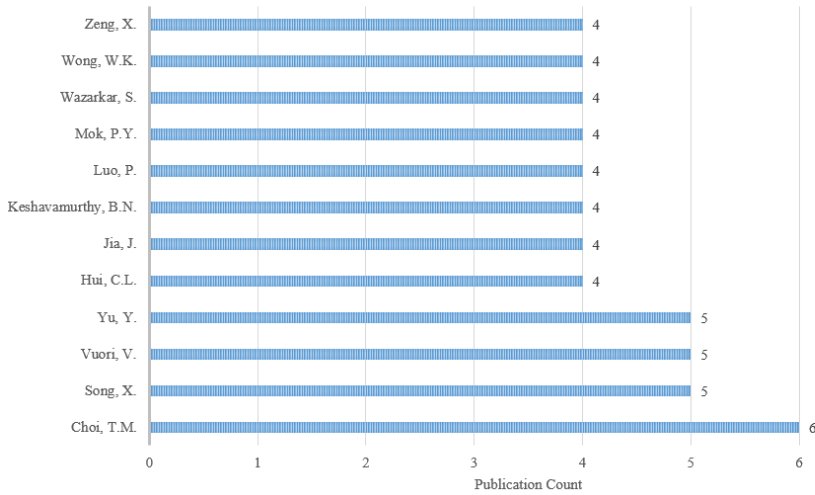### 2.2.10. Author based Statistical Analysis

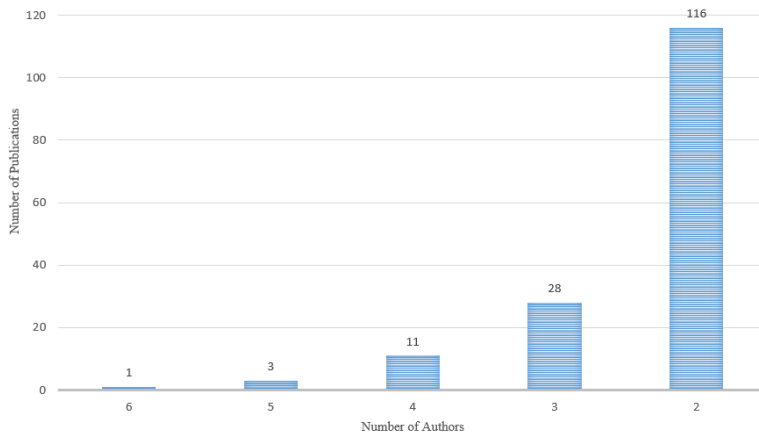Figure 12 Analysis of Authors and Publication Count

Figure 13 Representation of Author Count and Publication Count

Publication count per author is the basis for analysis in this subsection. In Figure 12, only authors with greater than or equal to 4 publication count are considered for illustration. Figure 13 is provided in order to get the information about the number of authors with respect to the count of publications. It is found that on an average 2 publications done by authors.

2.2.11. Citation based Analysis

Consideration of citations for analysis is very important as it is one of the important measures of usability of published work. In Table 6, Year wise citation count is provided. It shows that a total 5467 citation count is available for considered publications. Table 7 provides the yearly citation details for most cited publication i.e. "Ups and downs: Modeling the visual evolution of fashion trends with one-class collaborative filtering" which was published in 2016.

Table 6 Yearly Citations for Publications on Fashion using Artificial Intelligence

Year	<2016	2016	2017	2018	2019	2020	Total
Citations	1382	307	419	762	1411	1186	5467

Table 7 Details of Most Cited Publication

Publication Year	Document Title	Authors	Source	<2016	2016	2017	2018	2019	2020	Total
2016	Ups and downs: Modeling the visual evolution of fashion trends with one-class collaborative filtering	He R., McAuley J.	25th International World Wide Web Conference, WWW 2016	1	8	19	99	180	141	448

2.2.12. Funding Sponsors based Analysis

Total 132 funding sponsors contributed for research in the field of fashion using artificial intelligence. In Figure 14, funding sponsors associated with more than 3 publications are represented. Here, it is found that "National Natural Science Foundation of China" provided funding for maximum publications in this field i.e. 56.
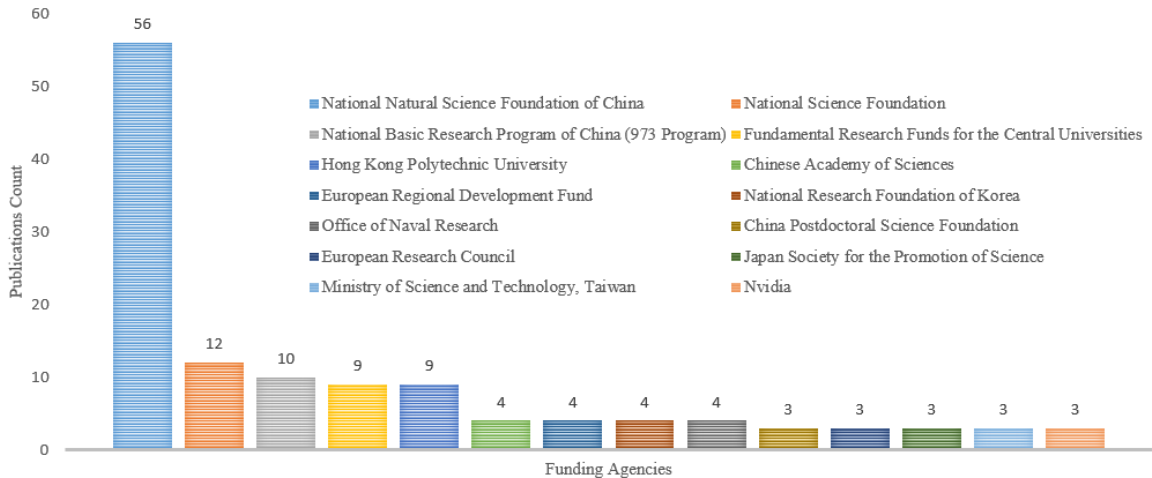

Figure 14 Analysis of Funding Sponsers and Publication Count

3.   Summarizing Comments on Bibliometric Analysis of Artificial Intelligence for Fashion Analysis

Solving tasks related to fashion and helping for making appropriate business decisions is very important from the perspective of fashion and textile industries. Artificial intelligence is a very good solution to solve problems in many fields. So use of artificial intelligence for fashion has increased these days. This study is targeted to

provide the quick review for research carried out in the specified area from different perspectives. For analysis, publications are considered with respect to various attributes like year of publication, language, authors, source titles, publication types, geographical location, citations and funding agencies. Along with it, network visualization is also provided to get the knowledge of relationships/ connections between different factors like keyword-source title, publication title-citations and author-co-authors. This bibliometric analysis will be very useful for new researchers in this field. It will be helpful for collaborating with potential researchers in this field, selecting appropriate sources to publish their research, to get the knowledge about funding agencies giving support to research in this area, identify new ideas with the help of keywords, etc.

Important findings of the bibliometric analysis of fashion using artificial intelligence:

- Become popular after 2015: Researchers turned their focus for research work in the field of fashion using artificial intelligence after 2015.
- Maximum publications in this field are available as conference papers followed by articles.
- English is preferred language for publications in this field; few papers in Chinese language are also available.
- Top three countries/territories contributed in this field: China, United States, India
- Maximum researchers from the subject area considered this field for their study: Computer Science and Engineering.
- Top contributing universities in this field: "Hong Kong Polytechnic University" and "Donghua University".
- Maximum publications of this area available in "Lecture notes in computer science" followed by "Advances in Intelligent Systems and Computing".
- "T. M. Choi" is the author who contributed a lot in the area of fashion.
- "Ups and downs: Modeling the visual evolution of fashion trends with one-class collaborative filtering" is the most cited paper in this field.
- Maximum funding received for research in this field from "National Natural Science Foundation of China".
- Tasks related to fashion needs special attention: Fashion forecasting and trend analysis, visual search, Fashion generation and manipulation, etc. (fashion recommendation also not an exception as it is also an demanding area and need to improvise through many perspectives)

Challenges in the field of fashion using artificial intelligence:

- Customer experience matters a lot
  - Customer personalization – It is important to incorporate personalization which has complications due to consideration of individual's data.
- Influencing factors – Need to be careful while considering influencing factors.
- Volume of data - Need to deal with large volumes of data/big data.
- Simple interface: Developed software should be simple and user friendly.
- Need to deal with unstructured data if data collected from different sources.
- Hardware constraints – As need to utilize large volumes of data and some techniques in deep learning needs devices with sufficient computational power.
- Virtual experience needs to tend towards natural experience.

4. Conclusion

Use of artificial intelligence in fashion is helping in transformation of fashion and textile industries from traditional to digital world. It is affecting many factors in the real world scenarios like shopping behaviour of customers, forecasting of demand based on which optimal pricing can be updated, etc. Looking at the applicability and efficiency this field of research is being important. In this study initially, we tried to throw light on recent publications accomplishing different fashion related tasks. Then, bibliometric analysis is carried

out using publications in fashion using artificial intelligence. Publication details retrieved from Scopus database using query having important keywords and utilized for the analysis. Findings of this analysis represents different viewpoints about research work done in this area. It is useful for the researchers while proceeding further in the similar field research. On the basis of analysis, it is found that use of artificial intelligence for fashion analysis got popularity in the last 5 years. There is a large scope for further research in this field. Keyword analysis is useful to decide the direction e.g. along with image analysis text analysis also useful in this field. It is also found that research related to fashion has its importance in different subject areas apart from business like material science, art and humanities, etc. which can be targeted by the researchers in future. Finally, challenges in the field of fashion using AI are mentioned.

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