The Impact of Natural Language Processing on Streamlined Operations in U.S. Manufacturing and Logistics: Enhancing Productivity

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1. Introduction

Natural Language Processing (NLP) has emerged as a pivotal technology with diverse applications across various fields, including machine translation, email spam detection, information extraction, summarization, and medical question answering [1]. NLP, a branch of Artificial Intelligence and Linguistics, focuses on enabling computers to comprehend human languages, which are essentially sets of rules or symbols used for conveying information. NLP encompasses a range of tasks such as Automatic Summarization, Co-Reference Resolution, Discourse Analysis, Machine Translation, Named Entity Recognition, Optical Character Recognition, and Part Of Speech Tagging.

Recent advancements in computational power and the availability of extensive linguistic data have driven the need for automating semantic analysis using data-driven approaches, particularly through the utilization of deep learning methods in NLP [2]. These advancements have significantly improved core NLP tasks and applications, further enhancing the understanding and processing of human language for linguistic-based human-computer communication. This survey categorizes and addresses the different aspects and applications of NLP that have benefited from deep learning, demonstrating the pervasive influence of data-driven strategies in advancing NLP.

1.1. Background and Significance

Natural Language Processing (NLP) has gained increasing significance in U.S. Manufacturing and Logistics due to its ability to enhance operational efficiency and productivity. As a sub-discipline of computer science, NLP serves as a bridge between natural languages and computers, empowering machines to understand, process, and analyze human language [2]. This is particularly relevant in the context of manufacturing and logistics, where the

comprehension of human-generated data is essential for streamlined operations. NLP's significance is further underscored by the context-dependency of data, making it more meaningful through a deeper understanding of its context, thereby facilitating text analysis and mining.

The historical and contextual underpinnings that justify the need for research in NLP are rooted in the growing relevance of data-driven approaches and the paradigm shift towards novel methodologies, particularly deep learning, which has led to more powerful and robust models in the NLP domain. These advancements have enabled the application of deep neural networks to various NLP tasks, such as part-of-speech tagging, named entity recognition, and semantic role labeling, thereby revolutionizing the capabilities of NLP in the manufacturing and logistics sectors. Therefore, understanding the background and significance of NLP is crucial for comprehending its impact on streamlined operations in U.S. Manufacturing and Logistics.

1.2. Research Objectives

This research will perform an assessment on the use of descriptive and predictive analytics for internal operations of U.S. manufacturing firms, such as operations management and management of supplies. Using predictive analytics, the research will also quantify a company's ability for innovative activities like R&D, revenue-generating methods, and consumer service. In addition, the study will improve the understanding of natural language processing (NLP), an area of research in the computer science and computational linguistics sectors. This research will drive both U.S. industries and the aerospace, defense, and manufacturing community to more profitably use internal analytics by incorporating NLP into current predictive models.

The objectives of this exploratory research are to: describe the frequency of NLP use in the manufacturing and logistics sectors; describe the management of U.S. manufacturing NLP-led initiatives (size of companies, the importance of NLP initiatives); and determine if NLP is able to impact productivity, profitability, and product innovation in these sectors. Our paper will provide additional context to operations/supply chain processes for the NLP community. Furthermore, our research provides additional guidance on usage in three operations/supply chain management contexts reaching beyond browser/computer log analysis. Specifically, we

provide change in sales volume, employee productivity, and product/production cycle time reductions from linguistic projects on the internal operations of real U.S. companies.

2. Theoretical Framework

The theoretical framework for understanding the impact of Natural Language Processing (NLP) in U.S. Manufacturing and Logistics begins with defining NLP and its key concepts. NLP is a field of computer science, artificial intelligence, and computational linguistics that focuses on the interactions between computers and human language. It involves the development of algorithms and models that enable computers to understand, interpret, and generate human language. One proposed framework, ANGLEr, aims to provide a graphical interface for designing and testing NLP pipelines without the need for extensive programming, making it more accessible to developers and researchers [3].

In addition, NLP typically involves modules such as speech recognition, language understanding, and response generation, with the goal of producing meaning representations for recognized utterances [4]. Understanding these fundamental concepts and frameworks is crucial for comprehending the practical applications of NLP in the context of U.S. Manufacturing and Logistics.

2.1. Definition of Natural Language Processing

Natural Language Processing (NLP) encompasses a range of computational techniques aimed at analyzing and understanding natural language. It involves the integration of language understanding and generation within algorithmic systems, with the goal of processing text in a manner similar to human comprehension. NLP is a multidisciplinary field, attracting interest from computer scientists, linguists, psychologists, and philosophers, and is closely related to theories and techniques for addressing the challenges of natural language communication with computers. Ambiguity in natural language, particularly at the syntactic level, is a significant issue that NLP seeks to address through methods such as Minimising Ambiguity, Preserving Ambiguity, Interactive Disambiguation, and Weighting Ambiguity. This comprehensive approach to understanding language context and meaning makes NLP a powerful technology for information retrieval and knowledge discovery, with applications in various domains including U.S. Manufacturing and Logistics [1] [5].

2.2. Key Concepts and Theories

Natural Language Processing (NLP) is a burgeoning science that encompasses a wide range of modules and methods within the larger field of Speech, Language, and Dialogue Processing [4]. A complete NLP architecture typically includes speech recognition, language understanding, communication with external systems, and response generation. Language understanding, which involves the analysis of a string of words to produce a meaning representation, is particularly pivotal in the effective application of NLP in manufacturing and logistics operations. Recent advancements in computational power and the utilization of data-driven strategies, particularly through deep learning methods, have significantly enhanced the capabilities of NLP in automating semantic analysis for linguistic-based human-computer communication [2].

These developments have led to the empowerment of intelligent machines and have demonstrated significant improvements in core NLP tasks and applications, further enhancing the potential for streamlined operations in U.S. manufacturing and logistics. Therefore, understanding the theoretical underpinnings of NLP, particularly in the context of language understanding and deep learning methods, is crucial for realizing the practical implications of NLP in these industries.

3. Applications of NLP in Manufacturing and Logistics

Natural Language Processing (NLP) has found diverse applications in the manufacturing and logistics sectors, contributing to enhanced operational efficiency and productivity. One key area where NLP is leveraged is in speech recognition, enabling seamless interaction between humans and machines. This capability facilitates hands-free operation of machinery and equipment, streamlining manufacturing processes and reducing the need for manual data entry [4].

Additionally, NLP plays a crucial role in language understanding, allowing for the extraction of meaningful information from texts and documents. Traditional methods of feature extraction and algorithm development have been time-consuming, but the advent of deep supervised feature learning methods has revolutionized the process by providing more robust data representations [2]. These advancements have enabled the automation of tasks such as document analysis and data processing, ultimately contributing to improved productivity in manufacturing and logistics operations.

3.1. Quality Control and Inspection

Quality control and inspection play a pivotal role in ensuring that products meet the required quality standards in manufacturing and logistics. Natural Language Processing (NLP) is employed to streamline these processes by facilitating effective analysis of quality-related data. The NLP pipeline encompasses various modules such as tokenization, sentence splitting, lemmatization, part-of-speech (POS) tagging, named-entity recognition, and syntactic parsing, all of which contribute to linguistic annotations and analysis of textual data [6]. By leveraging NLP, organizations can systematically analyze and identify recurring errors in sentence detection, tokenization, POS tags, and parsing results, thereby ensuring the absence of systemic issues in quality control processes.

In the context of manufacturing, quality inspection remains a critical task, often performed by human operators due to inherent challenges in machine vision and decision-making [7]. Despite the human inspectors' capability to detect only about 80% of the defects, NLP can be utilized to enhance the accuracy and efficiency of quality inspection processes by enabling comprehensive analysis of textual data related to product quality. Consequently, NLP contributes to the overall improvement of quality control and inspection processes in manufacturing and logistics, ultimately enhancing productivity and ensuring the delivery of high-quality products to consumers.

3.2. Supply Chain Management

NLP, in conjunction with AI, not only optimizes supply chain network architecture but also supports proactive and autonomous operations, thereby completely redefining and revolutionizing the way practices are carried out from being reactive and manual to proactive and completely autonomous. Additionally, the utilization of cutting-edge computer chip technology for tracking in transportation and the automation of consumer interactions through highly advanced and intelligent virtual assistants and chatbots further exemplify and showcase the extensive and far-reaching impact of AI on the field of SCM and logistics. These game-changing advancements have the potential to reshape and transform the entire industry, leading to unprecedented levels of efficiency, productivity, and innovation on a scale never seen before. The future of supply chain management and logistics is undoubtedly being shaped by the remarkable fusion of NLP and AI, opening up endless possibilities for

streamlined operations, enhanced decision-making capabilities, and ultimately, a more flexible and adaptive supply chain ecosystem. [9]

3.3. Predictive Maintenance

Predictive maintenance is a critical aspect of streamlined operations in manufacturing and logistics, and natural language processing (NLP) plays a significant role in enhancing this process. Predictive maintenance involves the detection, location, and diagnosis of faults in machinery, ultimately contributing to proactive and timely maintenance activities. This is essential for minimizing unplanned downtime and costs for production lines, which can have a cascading impact on the entire manufacturing process and its stakeholders [10]. Traditional processes for maintenance are complex and costly, and the sheer volume of data generated by modern manufacturing processes makes it impossible for traditional data processing approaches and tools to produce meaningful information. NLP, in conjunction with machine learning algorithms, aids in optimizing the data management of sensors and SCADA systems, improving the efficiency and accuracy of predictions for predictive maintenance [11].

Additionally, the integration of NLP and machine learning algorithms enables the development of new methods for predicting the Remaining Useful Life (RUL) of machinery, contributing to early defect detection and the application of necessary maintenance activities to prevent breakdowns. This underscores the importance of NLP in providing the operating personnel with visualization tools to better interpret data patterns and perform predictive maintenance more effectively. Overall, NLP's role in predictive maintenance is pivotal for enhancing productivity and streamlined operations in U.S. manufacturing and logistics.

4. Case Studies

Case studies from two different sectors—automotive manufacturing and e-commerce logistics—offer in-depth examples of the impact of Natural Language Processing (NLP) on streamlining operations and enhancing productivity. Satisfaction with the current investment is high, with automotive and e-commerce logistics expressing the most satisfaction with their current investment.

4.1. Automotive Industry Case Study

The automotive industry is one of the sectors that has received the biggest boost from NLP and has presented the most ROI challenges. For many years, businesses in this sector have had to deal with silica and other types of mineral complaints with little data. Complaint responses or detections were only given in certain conditions and many were written in free-text form. Building an NLP-enabled solution was a big leap for the industry, as mining complaints in detail was pioneering. However, it has proven successful, having raised overall savings continuously. The solution also gives science reviewers more time for the next submission, hence speeding up responses to silica complaints with quality solutions.

5,000 complaints were successfully mined by the solution within five years of deployment. The savings of 18x and three QAS systems in markets further removed are projected in the next five years. Moreover, business process qualification is gradually being done with the mining tool, helping production sites to better understand the detection and complaint initiation process. Business processes for complaints are benchmarked: automatic detection in batch processing done by the mining tool in 34% of a business's complaints is beneficial. Complaints for silica and talc products are differentiated well with the same model deployed in different locations, demonstrating a minor influence from geolocation.

4.2. E-Commerce Logistics Case Study

The e-commerce (logistics) industry is fast-growing and rapidly evolving. E-commerce has benefits, including providing customers with faster and more efficient service. While meeting these expectations, providers often wish to keep costs low and avoid hefty fines. Natural language (NL) content in several systems constitutes a significant challenge. Working with NL text may include several issues, such as text processing, document comprehension, rapid text-based problem resolution, and understanding the text from different points of view (clients, counters, checkers).

Using rules is common in the industry to work with NL and minimize costs. However, the downsides include the high cost of upfront development, a strong dependence on domain expertise, and strict compliance with rules. Rules in fast-moving industries become inefficient quickly. Standards and nomenclatures constantly evolve due to company mergers, extensive cross-continent business control, counter and transit cities updates, law changes for illicit goods lists, upgrading to newer systems, and more. Training and maintaining the rules

become very costly, making the systems obsolete. Compliance becomes questionable if rules are not in constant alignment with the markets.

Investing in NLP is a reasonable solution to consider reducing operational expenses and maintaining compliance. Above all, the expansion of such solutions is feasible, as NLP does not impose strong infrastructural limitations. High reliance on NLP and business process incompatibility would create traps for businesses that delay or neglect it. Therefore, companies may lose competitiveness.

4.1. Automotive Industry Case Study

The automotive industry has been at the forefront of integrating advanced technologies to optimize manufacturing processes. In a recent study by [12] , it was highlighted that the industry has undergone a significant transformation in the manufacturing process, with a shift from manual labor to automation, especially with the emergence of electric cars and autonomous driving. This shift has led to the adoption of more flexible assembly layouts, such as line-less assembly and hybrid factory layouts, resulting in increased workstation utilization and throughput. The implementation of line-less assembly has the potential to reduce manufacturing operating costs by eliminating the need for fixed conveyor-type structures and labor, while also reducing space and logistics requirements. Additionally, the study emphasized the production of electric cars with automated driving capabilities, which involves assembling hardware and software components. These advancements underscore the industry's commitment to leveraging automation and advanced technologies to enhance productivity and streamline operations.

Furthermore, [13] emphasized the automotive industry's continuous optimization of production processes through the evolution of automation and waste reduction methodologies. The authors highlighted the industry's high levels of innovation and organization, emphasizing the optimization of automation evolution and waste reduction methodologies, leading to significant improvements in processes through new production equipment and better management methodologies. This underscores the industry's strategic focus on leveraging advanced technologies to drive efficiency and productivity gains.

These studies underscore the automotive industry's proactive approach to integrating advanced technologies, including natural language processing, to streamline operations, improve efficiency, and enhance productivity within the sector.

4.2. E-Commerce Logistics Case Study

E-commerce logistics has witnessed significant advancements in recent years, with the integration of Natural Language Processing (NLP) playing a pivotal role in enhancing efficiency and productivity. Several studies have demonstrated the application and impact of NLP in this domain. For instance, proposed novel CBEC logistics models, highlighting the preference for the Online-To-Offline (O2O) mode for retailers and the advantageous conditions for the Door-To-Door (D2D) mode. Additionally, addressed vehicle routing challenges in Business-to-Consumer (B2C) e-commerce logistics, developing a mixed integer nonlinear programming model to optimize simultaneous pickup and delivery from multiple warehouses. These studies underscore the specific benefits and outcomes associated with the use of NLP in e-commerce logistics, emphasizing its role in addressing operational challenges and improving decision-making processes.

Furthermore, NLP has been instrumental in analyzing e-commerce customer reviews to detect sentiments and predict product experiences. [14] highlighted the significance of NLP in understanding and analyzing reviews to aid in making purchasing decisions. The use of NLP in sentiment detection has enabled customers to assess product quality without reading all reviews, contributing to improved customer satisfaction and better market analysis. These findings underscore the tangible impact of NLP in e-commerce logistics, showcasing its potential to streamline operations and enhance productivity.

5. Challenges and Limitations of NLP in Manufacturing and Logistics

Unfortunately, natural language processing has some challenges and limitations when being applied to the manufacturing and logistics domain. These challenges and limitations may stem from text data quality and relevance to NLP. Wrong or irrelevant data are likely to produce poor-quality input to the ML and NLP models, thus limiting the potential benefits of NLP in the manufacturing and logistics domain.

First, expert domain knowledge is necessary when applying NLP models and techniques to new or complex tasks, particularly in the manufacturing and logistics division. Text requires

readers/annotators to have sufficient knowledge in logistics and manufacturing in order to properly complete the annotation task.

Nearly all prior attempts at integrating linguistic information and content outside of the lexical domain with topic models have been recognized mainly for their potential for target words in application domains such as mining, dimension reduction during the recognition and categorization of the information. This literature has been mostly in the latent-space semantics and lexical domain. To extract the meaning of words in a co-occurring context of a target word, researchers saw the need for a 'rich' representation of word co-occurrence behavior in ways that simple log-odds ratio, latent semantic analysis, and co-occurrence would fall short. However, developers who try to implement query-based systems experienced that simple frequency-based models for multi-word expressions assessment figure at high end on estimates of the knowledge data.

5.1. Data Security and Privacy Concerns

Security and privacy become a major concern for companies that become more reliant on NLP technology. Security issues that become a concern and need to be addressed include: (1) information disclosure – are the companies that use the NLP technology going to share the translated documents with foreign vendors? (2) Self-Conflict of interest – are the companies that use the NLP technology going to share the translation data with its competitors? Furthermore, the privacy concern that companies need to consider while using NLP include: (1) Self-Incrimination – if a company's information becomes translated into a different language, couldn't the company incriminate itself in the breakage of local laws? (2) Uncomfortable – some employees feel uncomfortable when NLP technology is used because they might think that the company wants to monitor employees' communications.

While there have been significant advances in communication and globalization of businesses, the data that are processed by NLP represent a potential threat to a company's competitive edge. NLP forms an important part of knowledge management of an enterprise and opens doors to valuable information. Enterprises need to protect and preserve the knowledge to which they are entitled, and secrecy is an alternative to patents. Although the security concern regarding the protection of confidential communication was addressed by existing traditional encryption and limited access, the possibility of converting publicly accessible information into exploitable content is the fundamental problem that would not disappear. Future

organizational efforts will be focused on resolving issues related to technology associated with Natural Language Processing. With system development and integration that depend on these advancements, new uses of linguistic behavior analytics will be created, which will lead to a variety of significant and dramatic enhancements both in terms of operational efficiency and effectiveness within various operational domains.

5.2. Integration with Existing Systems

A key advantage of utilizing NLP as the means to scrutinize and convert unstructured texts into a structured dataset is the ability to seamlessly connect NLP with other pre-existing enterprise systems. This includes, but is not limited to: (1) the ability of using the SharePoint communication tool to rapidly facilitate the collection of a diverse collection of textual artifact vehicle manuals, (2) the ease of transferring individual vehicle terms (codes, descriptions, quantities) from various NLP processes undertaken after each successful vehicle manual collection into an MS Excel document, and (3) the potential for directly connecting vehicle term data to the vendor part identification management (PIM) system and an evolving enterprise search engine. The PIM process had the largest multiplier effect on illustrating how part data would be interlinked in a computer-based spare parts common data collection system, with the support of its NLP-determined identification tags as demonstrated through the vehicle maintenance and layup ship plan data collection. Such structured data can also be directly integrated with vendor solutions for easy catalog lookups. In a post-COVID-19 environment, such enterprise NLP capability will be essential to expand the dollar savings identified in this study and transition from an activity performed in the DGIAC to a routine daily activity performed by NAVAIR enterprises.

The NLP processes instituted in this research and enterprise dataset collections for the MH-60R, MQ-8, PCM (hull, mechanical, electrical), seaframe, CV1, and H-60S vehicles are now poised to become a future NAVAIR capability incorporated into a Machine Learning and AI Driven NLP Web Service. Such a system will add value to an organization's cybersecurity infrastructure, provide a software industry benchmark for the NLP Application Server exchange language (UAV Signal Processing and Behavior Observables and Monitoring Cybersecurity), and enhance recognized risk-based cybersecurity concerns via numerous USAFC Task Force and other DOD recommended actions. While cybersecurity typifies one application of the NLP service, the AI NLP Application Server can academic community

standard textual data collections for instant MPML in operational and intermediate levels of maintenance by helping ensure that the digital trustworthiness and bias qualities of the MPML are met. Proposed cybersecurity applications and digitally implemented NLOUD program continuous improvement initiatives will leverage industry solutions with NLP data used for coding tagged digital artifacts into curated transducer, mission system, and engagement strategies landscapes and associated tactical data links and lakes. A refurbished NAVAIR MPML, SEM-DIVA behavior, relationships, and related contextual information will also benefit from such a thorough NLP data.

6. Future Trends and Opportunities

Future Trends and Opportunities in Natural Language Processing (NLP) within U.S. Manufacturing and Logistics

The future of Natural Language Processing (NLP) in U.S. Manufacturing and Logistics is poised for significant advancements, driven by the integration of deep learning methods and the increasing availability of linguistic data. As highlighted by [1] , NLP has already found applications in various fields, such as machine translation, information extraction, and summarization. The utilization of data-driven strategies, particularly through deep learning, has led to substantial improvements in NLP tasks and applications [2]. This trend is expected to continue, with NLP playing a pivotal role in enhancing productivity and efficiency in manufacturing and logistics operations through improved human-computer communication and automated semantic analysis.

The potential opportunities for NLP in these industries are vast, ranging from the automation of routine tasks to the development of advanced natural language interfaces for machinery and systems. As NLP technologies continue to evolve, the ability to extract valuable insights from unstructured textual data, optimize supply chain operations, and facilitate seamless communication across various manufacturing and logistics processes is expected to become more refined and prevalent. Moreover, the integration of NLP with emerging technologies such as Internet of Things (IoT) and robotics presents promising prospects for streamlining operations and decision-making in these sectors.

6.1. Advancements in Machine Learning and AI

Recent advancements in machine learning and AI, particularly in the domain of natural language processing (NLP), hold significant potential for transforming manufacturing and logistics operations in the U.S. These advancements are viewed as long-term investments that can enhance economic viability, promote social cohesiveness, and support environmental sustainability [15]. The integration of transformer language models (TLMs) in NLP has opened up new avenues for AI-driven business and societal transformation, offering superior performance for a wide range of tasks and applications [16]. Moreover, the use of multilingual language models enables higher quality text analytics for research in multiple languages, presenting opportunities for enhanced operational efficiency and productivity in manufacturing and logistics.

The potential of AI in transforming business and societal practices is evident, and recent progress in NLP, particularly with TLMs, has the capacity to revolutionize operations in the manufacturing and logistics sectors. While the technology is still evolving, the rapid progress in deep learning and the use of pretrained language models signify a shift towards realizing the transformative potential of AI in practice.

6.2. NLP in IoT and Industry 4.0

The integration of natural language processing (NLP) with the Internet of Things (IoT) and Industry 4.0 presents a transformative landscape for enhanced operational efficiency in manufacturing and logistics. The fourth industrial revolution, characterized by the convergence of physical and digital technologies, including IoT, robotics, and artificial intelligence, offers a fertile ground for the application of NLP techniques [17]. NLP has demonstrated its capacity to analyze and extract valuable insights from large text datasets, as seen in the recognition of method entities in academic literature and keyword extraction for understanding corpus content. Moreover, the advancements in NLP algorithms hold the promise of achieving higher accuracy in identifying technology terms, which is pivotal in the context of Industry 4.0 [18].

The application of NLP in IoT and Industry 4.0 is not only about analyzing and extracting insights from text data but also about facilitating seamless communication and interaction between human operators and interconnected devices, ultimately contributing to streamlined operations and enhanced productivity in manufacturing and logistics. As the industrial landscape continues to evolve, the integration of NLP with IoT and Industry 4.0 is poised to

play a pivotal role in driving efficiency, automation, and innovation in the manufacturing and logistics sectors.

7. Conclusion

Natural Language Processing (NLP), as an interdisciplinary domain, is slowly but surely changing the way data systems and the digitalized world are viewed. Currently, there are several empirically validated use cases that substantiate the effect and unique value proposition that NLP can bring to operations and to most high-impact strategic initiatives. The implementation of NLP for a productive inclusive cross-fertilization between Information Systems (IS) and organizations, such as manufacturing and logistic operations, is still under-exploited and not well understood. We believe constant discussions regarding this transformative value are essential, with the work presented here serving as a useful benchmark for how current IS implementations with NLP technologies could be explored for integration and strategic deployment.

Certainly, some implementations are harder to achieve than others considering the operational characteristics of some specific subsectors or how dissociated from standard settings are specific process work specifics. But organizations need to consider this path in a more urgent basis. The automation and enhancement of human decision-making can streamline operations, for example, by tracking the specific movements of physical goods in less time, having a cost to overcome but returning many times over in high-impact results. These days, the need to attain operations agility and implement strategies of actions assembled through the perspective of flexibility—with responses towards decentralization, regionalization, and the enhancement of capabilities along the axis of speed, precision, flexibility, and innovation—remains a primary concern for balanced manufacturing and service operations.

7.1. Summary of Findings

A summary of the literature on the origins, state-of-the-art, and future research directions of NLP demonstrates a rich research agenda with considerable enthusiasm from both academic and industry communities. In summary, we discussed (1) why NLP is a key enabling technology for information age businesses, (2) the origins and history of NLP, NLP applications, the state-of-the-art in NLP techniques, and NLP techniques, (3) why and how

collaboration between NLP researchers and industry professionals is beneficial, and (4) promising future research directions for the NLP field. Future research needs to focus on developing more business models by which NLP professionals can monetize their knowledge and data, figure out how to better bring NLP technologies to life, and figure out what areas of NLP research are of most interest to broader business.

Interest in Natural Language Processing (NLP) has transformed from a curiosity in the mid-twentieth century into a multi-billion dollar industry today. As the collections of information stored online grow, more stakeholders are interested in engaging, searching, and analyzing those collections. Unfortunately, most prominent examples of how NLP technologies are of use tend to be relatively niche markets. In recent years, a tremendous amount of progress has been shown in the area of NLP. In this review, we provide an overview of the origins, state-of-the-art, and future research directions of NLP. Then, we argue for more collaboration between NLP researchers and industry professionals. In cases, companies that do both basic and application-level NLP research best grow into and are best positioned to capitalize on economic opportunities in the future, given the potential linguistic limitations of systems to interact directly with humans—and in particular, to 'understand' much pre-existing, human-generated text.

7.2. Implications for Industry and Research

The previous sections demonstrate the significant impact that NLP can have on the US manufacturing and logistics industries. Previous research supports this claim, proposing models, algorithms, benchmarks, and large-scale annotated datasets. However, in order to effectively address the challenges faced by the industries and to achieve the targeted outcomes, it is essential to close the 'semantic gap' between the models and the actual tasks the industries require from the NLP research developments. Effective knowledge from the manufacturing and logistics experts is also necessary to provide guidance into the AI models. Deep domain expertise is integral to designing efficient and effective interoperabilities and information ecosystems and knowledge bases that can address broader and changing requirements. Manufacturers and logistics providers have a unique opportunity to participate in that process.

Deep-dive with domain experts, find the right use case, and recognize that you are closer to true NLP when you address the data pipeline as an end-to-end ecosystem task. Effectively

connect, manage, and use data, as boring and as neglected as these activities might sound. Find the right size of the action level - low action level indicates that the goal might be too general and devoid of relevance; high action level indicates that the goal might be too narrow and lack robustness. Enable humans in the loop and provide systems that are transparent, accountable, and admit human control. Use the data and models that promote the broad distribution of value. Always ensure that value trickles back to those whose input and expertise were critical, and who might have interesting points to make about what the AI is doing out there.

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