

Demand forecasting related applications of Artificial Intelligence and Machine Learning in Travel & Hospitality Industry

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ABSTRACT

This research paper primarily investigates the impact of various artificial intelligence (AI) and machine learning (ML) applications on demand forecasting in the context of travel and hospitality sectors. As the accuracy of demand forecasting is vital for revenue management but traditional methods often fails to predict the demand by higher accuracy due to their reliance on historical data and outdated techniques, which generally overlook real-time variables such as economic shifts, changing preferences and unforeseen events. The current study employs a systematic literature review to identify various AI and ML applications based studies and collects the data from industry experts who provided their opinion on emerging AI, ML technologies and responded on various applications with their advantages and future concerns. The paper also addresses challenges in implementing AI-based forecasting systems, such as data quality and the need for human supervision. The study majorly reveals that most of the experts are positive about the assistance being provided by AI and ML in demand forecasting with high accuracy at lower costs, but they are also very much concerned about loss of jobs and lower transparency of decision making criteria of AI and ML technologies. Most of the respondents were also in favour of human supervision and control over AI and ML applications.

Keywords–Artificial Intelligence (AI), Machine Learning, Travel and Hospitality Industry.

INTRODUCTION

The travel and hospitality industry is an ever changing and complex sector that demands constant innovation to meet the evolving expectations of travellers. In past few years, the incorporation of AI and ML have emerged as a transformative push, reshaping how businesses forecast demand and optimize operations. This study investigates the applications of Artificial Intelligence and Machine Learning in demand forecasting within travel and hospitality industry, highlighting their potential to enhance efficiency, personalize customer experiences, and drive growth.

A. Role of Demand Forecasting in Travel & Hospitality

Demand forecasting is a crucial element of operations in the travel and hospitality sector. It involves predicting future customer demand to take conscious decisions related to promotions, pricing, service feature and provisions. Accurate demand forecasting enables businesses to optimize inventory, reduce waste, and improve customer satisfaction by lining up supply with forecasted demand.

In the context of travel and hospitality, demand forecasting is particularly challenging due to the sector's inherent volatility. Influences such as seasonality, economic circumstances, and consumer preferences can substantially affect demand patterns. Traditional forecasting methods often struggle to capture these complexities, necessitating the adoption of more sophisticated techniques.

B. Applications of Artificial Intelligence and Machine Learning in Demand Forecasting

The integration of Artificial Intelligence and Machine Learning in demand forecasting has led to several innovative applications within the travel and hospitality industry:

- **Dynamic Pricing:** Artificial Intelligence and Machine Learning driven dynamic pricing models can adapt prices in real-time based on demand fluctuations, competitor pricing, and other industry factors. This approach maximizes revenue by ensuring prices reflect current demand conditions.

- **Inventory Management:** AI and ML enable more precise inventory management by predicting demand for specific services or products, such as hotel rooms or airline seats. This helps businesses improve service levels and decrease costs linked with carrying costs of stocks.
- **Personalized Marketing:** By analyzing customer data, AI and ML can design tailored marketing drives that target peculiar customer sections with tailored offers. This personalization enhances consumer engagement and drives demand.
- **Resource Allocation:** AI models can forecast demand for various services, such as housekeeping or dining, allowing businesses to allocate resources efficiently. This ensures optimal staffing levels and service quality during peak periods.

C. Challenges and Considerations

While AI and ML offer significant benefits for demand forecasting, their implementation is not without challenges:

- **Data Quality and Availability:** The accurateness of Artificial Intelligence and Machine Learning applications depends on the quality and availability of data. Inadequate or biased data can lead to inaccurate forecasts.
- **Integration with Existing Systems:** Incorporating AI and ML with traditional systems can be difficult and may require significant investment in infrastructure and training.
- **Ethical and Privacy Concerns:** The use of Artificial Intelligence and Machine Learning raises ethical and privacy concerns, specifically in collection and use of users' data.

LITERATURE REVIEW

AI and ML technologies have been increasingly applied in demand forecasting, offering more precise and efficient solutions compared to traditional methods. These technologies leverage vast datasets to recognize trends, allowing businesses to make insight-driven choices. According to Yu and Chen (2021), Artificial Intelligence and Machine Learning models such as neural networks and support vector regression (SVR) have been effectively used in tourism demand forecasting, significantly improving forecasting accuracy.

A. Key AI and ML Techniques in Demand Forecasting

- **Machine Learning (ML):** ML algorithms are extensively used for demand forecasting to support vector machines and decision trees. These algorithms process enormous datasets to recognize complex patterns and relationships between variables (Henriques & Pereira, 2024).
- **Deep Learning (DL):** DL models, particularly neural networks, have shown great promise in demand forecasting. These models capture non-linear relationships and learn from vast volumes of data, transforming them suitable for complex forecasting tasks (Yu & Chen, 2021).
- **Natural Language Processing (NLP):** NLP techniques provide valuable insights into consumer preferences and trends (Saydam et al., 2022).
- **Recommender Systems:** These systems utilize collaborative filtering and content-based filtering to suggest personalized travel and accommodation options. By influencing customer preferences, recommender systems can impact demand patterns and enhance customer satisfaction (Tomczyk et al., 2022).

B. Previous studies on AI and ML Techniques in Demand Forecasting within Travel & Hospitality Industry

Recent researches highlight that AI & ML tools are progressively applied to demand forecasting in the travel and hospitality industry. These methods offer improved accuracy over traditional approaches for predicting hotel occupancy rates, tourism demand, and travel patterns (Henriques & Pereira, 2024; Caicedo-Torres & Payares, 2016). Various AI/ML models, including neural networks, deep learning, and hybrid models, have been explored for forecasting applications (Sison et al., 2021; Doborjeh et al., 2021). Recent advancements incorporate clustering techniques and additional features to enhance prediction accuracy (Kaya et al., 2021). These days, AI & ML implementations in the industry extend beyond forecasting to include personalization, recommender systems, and smart travel agents (Bulchand-Gidumal, 2020). While AI/ML methods show promise in improving forecasting accuracy and decision-making, challenges remain, such as data quality issues and the need for computational expertise (Henriques & Pereira, 2024; Dalimunthe et al., 2023). Ongoing research aims to refine these techniques and address industry-specific challenges. An account of few recent studies are as follows:

In a literature review study by Henrique Henriques and Luis Nobre Pereira (2024), they identified the key gaps in AI-based hotel demand forecasting literature and concluded that AI technology can significantly improve forecasting accuracy and support data-driven decision-making in hotel management. Whereas William Caicedo-Torres and Fabián Payares (2016), explored the applications of ML techniques to forecast daily hotel occupancy rates based on historical booking and occupancy data. They concluded that ML models can produce promising results in forecasting hotel occupancy rates and demand. The study also explored various approaches to dataset construction and model validation for developing effective occupancy rate forecasting models. Nicolai Sison, Lin Li and Meng Han (2021) surveyed the classical and modern ML especially deep learning techniques for forecasting travel demand in the face of evolving

industry dynamics and the need for more advanced forecasting models. Their study majorly concluded that there is a need for more advanced and hybrid forecasting models to address the challenges in predicting travel demand. Z. Doborjeh, N. Hemmington, M. Doborjeh and N. Kasabov (2021), provided a systematic literature review on future directions of AI and ML applications in tourism industry. Authors largely proposed that due to complex nature of demand forecasting, companies should develop their own AI models for smart tourism platforms in order to effectively predict customer behaviour patterns. The study of Kıymet Kaya, Yaren Yılmaz, Y. Yaslan, Ş. Öğüdücü, and Furkan Çıngı (2021), organized the existing literature on travel demand forecasting, covering both classical and modern techniques. As per their study, Travel demand forecasting is becoming more challenging due to the evolving dynamics in the accommodation sector and the emergence of new travel alternatives. They also proposed demand forecasting model using Attention-LSTM and hotel clustering features.

The study of J. Bulchand-Gidumal (2020), provided an overview of how artificial intelligence is being used in the travel, tourism, and hospitality industries, covering the key areas of applications, the enabling technologies, and the challenges and future outlook for AI in this sector. The study of Sri Baginda Dalimunthe, Rosnani Ginting, and S. Sinulingga (2023), reviewed the use of machine learning in demand forecasting, comparing the accuracy of different models, methods, and variables, and finding that the appropriate approach needs to be selected based on product characteristics to achieve high forecasting accuracy, which also requires continuous model updates. The study of Elliot Mbunge, and Benhildah Muchemwa (2022), concluded that AI and ML based forecasting model should base on the characteristics of the product, and choosing the wrong model can reduce forecasting accuracy. Also the forecasting models need to be updated over time to maintain high accuracy level. Aamer, Luh Putu, Eka Yani, I. Made, and Alan Priyatna (2020) provided a comprehensive overview of ML applications in demand forecasting and their potential to improve supply chain efficiency, with a focus on the most widely used algorithms and the practical implications for industry stakeholders. In the two different studies- 1) The studies of Xin Li, Hengyun Li, B. Pan, R. Law (2020) and 2) Amandeep Kaur, Sonali Goyal, and N. Batra (2024), authors investigated how the use of Internet of Things (IoT) and machine learning (ML) can transform the hotel industry by improving demand forecasting, predictive analytics, and customized guest experiences, while also addressing the ethical and data security challenges. Studies also examined the potential of incorporating Internet of Things (IoT) devices to establish smart and networked hotel settings, promoting energy conservation and real-time monitoring. The research of L. Cain, John H. Thomas, and Miguel Alonso (2019) reviewed the current research on the use of robotics and AI in the hospitality and tourism industry. And examined the implications of using robotics and AI in areas such as customer service, legal and ethical considerations, and theoretical implications. The study offered scholars an overview of the current state of knowledge in this rapidly evolving field.

RESEARCH OBJECTIVES

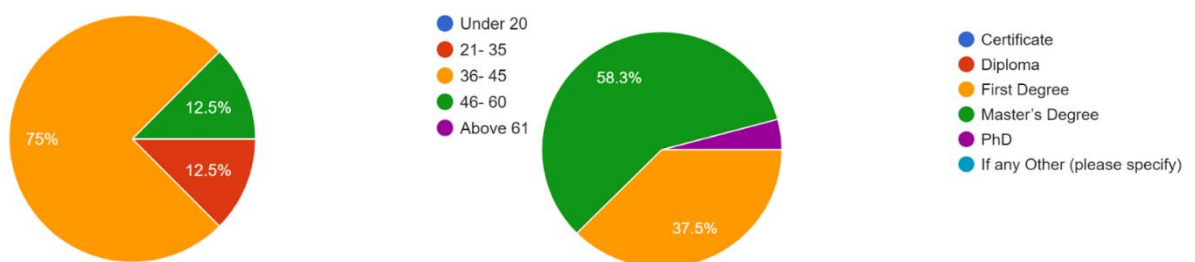
The study has the following objectives to:

- Analyse and evaluate the behaviour/attitude of the managers and industry experts towards AI and ML applications in general.
- Evaluate the perception of managers and industry experts towards various threat and opportunities in personal as well as in the context of tourism demand forecasting.

RESEARCH METHODOLOGY

The study utilises both primary and secondary data research methods to achieve the objectives. First it evaluates various studies from the past to develop an understanding of previous researchers to build the knowledge, application and challenges of AI and ML in the context of Travel and Hospitality industry. Second, it uses the questionnaire method to collect primary data from various managers and experts from Travel and Hospitality industry to evaluate their opinion and attitude towards various applications of AI and ML in demand forecasting.

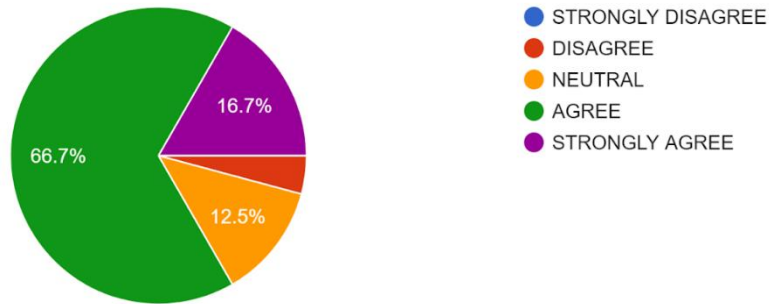
RESEARCH RESULTS, ANALYSIS AND DISCUSSION



For the purpose of analysis, the study collected the data from a small number of respondents (24 respondents) due to its major restriction that the respondents should be either an industry experts and managers/ employee/ supplier of services in Travel and Hospitality industry. The respondents' profile indicate a group of 71% males and 29% females where they belonged to the age group of 36-45 years, majorly having their master's degree.

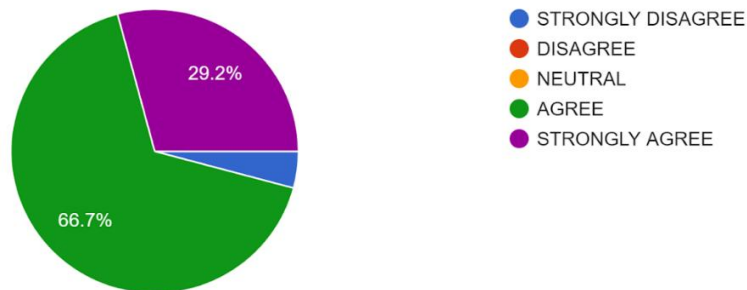
A. Personal Attitude towards AI/ML

Q.1. I believe that AI/ML will improve my life.



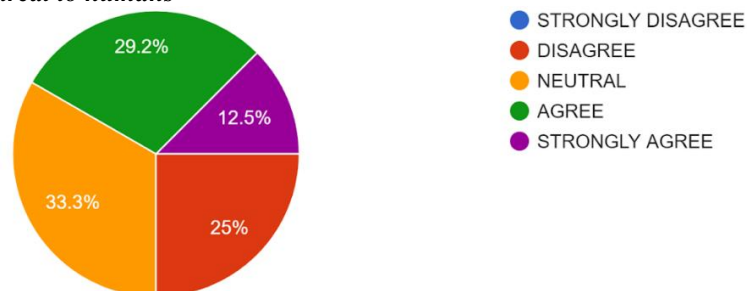
When the respondents were asked about their *belief that AI/ML will improve their life*, the majority of respondents-66.7%, agreed with the statement while 16.7% replied with ‘strongly agreed’ with the statement indicating - most respondents believe that AI / ML will be improving their lives. Whereas only 12.5% were neutral with the statement. Hence, from the above results we can infer that the majority of people believe that AI and ML is going to improve their lives.

Q.2. I believe that AI/ML will improve my work.



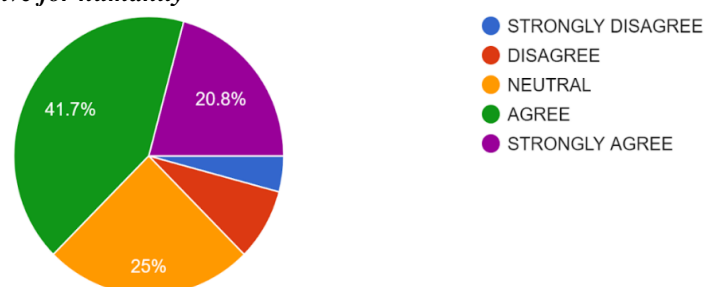
When the respondents were asked about their *belief that AI/ML will improve their work*, the majority of respondents-66.7%, agreed with the statement while 29.2% replied with ‘strongly agreed’ with the statement indicating - most respondents believe that AI / ML will be improving their work. Whereas only 4.2%% were strongly disagreeing with the statement. Hence, from the above results we can infer that the majority of people believe that AI and ML are going to improve their work.

Q.3. I think AI/ML is a threat to humans



When the respondents were asked about their belief that AI/ML is a threat to humans, 33% were neutral, 29,2% agreed, 12.5% were strongly agreeing and 25% disagreed. Hence most of the respondents believed that AI/ML is a threat to humans. We can infer from results that for the majority it’s a threat.

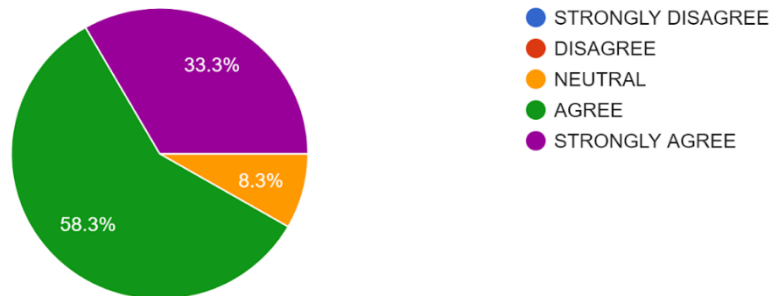
Q.4. I think AI/ML is positive for humanity



When the respondents were asked about their belief that AI/ML is positive for humanity, the majority of respondents-44.7%,agreed with the statement while 20.8% replied with ‘strongly agreed’ with the statement indicating - most respondents believe that AI / ML will be improving their work.Whereas 25% were neutral towards the statement. Hence, from the above results we can inferthat the majority of people believe that AI and ML is positive for humankind.

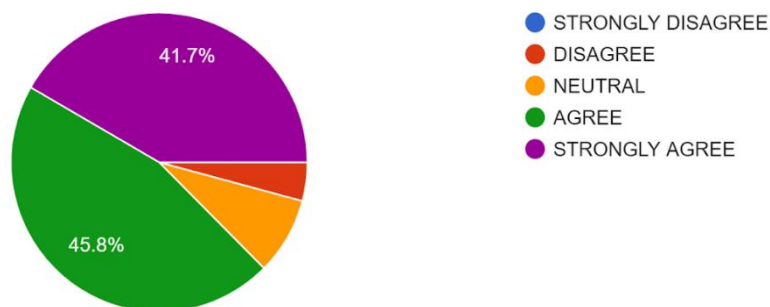
B. Personal Opinion about usage of AI/ML in Tourism Industry in the context of Demand Forecasting

Q.5. I think there are numerous application advantages of AI/ML in demand forecasting



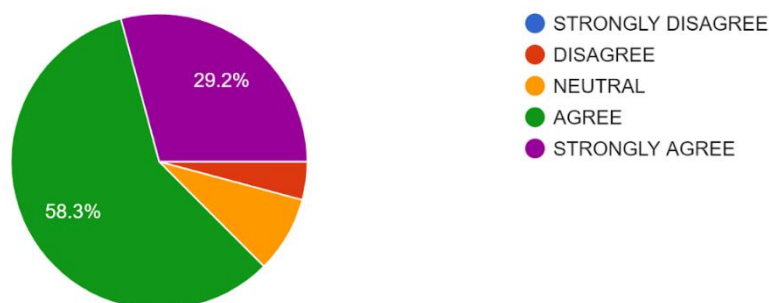
When the respondents were asked about their belief that AI/ML has numerical advantages, the majority of respondents- 58.3%, agreed with the statement while 33.3% replied with ‘strongly agreed’ with the statement indicating - most respondents believe that AI / ML have numerous advantages. Whereas only 8.3% neutrally reacted with the statement. Hence,from the above resultswe can infer that the majority of people agree and believeabout the same.

Q.6. I think AI/ML performs better than humans in demand forecasting



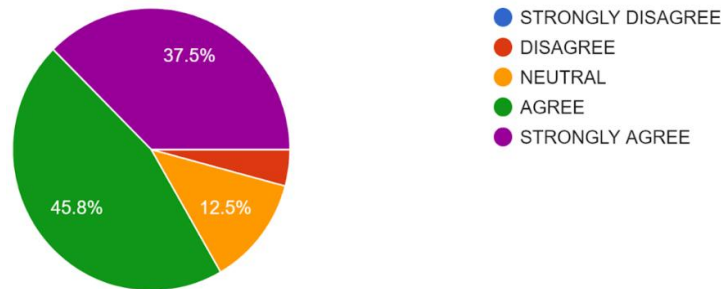
When the respondents were asked about their belief of AI/ML performing better than humans indemand forecasting, the majority of 45.8% agreed, 41.7% strongly agreed indicating most respondentsbelieving about the better performance performedby AI/ML. 8.3% of people were neutral and 4.2% disagreed. Hence, we can infer that majority of people agree and believe about the benefits of people.

Q.7. I think AI/ML is less biased than humans in demand forecasting



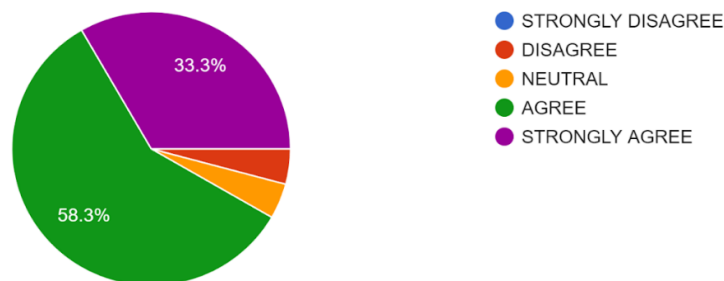
When the respondents were asked if AI/ML is less biased,majority of 58.3% of agreed, 29.2% strongly reacted and hence the statement indicates about people believing about the positive side of AI/ML about being less biased. 8.3% were neutral and 4.2% disagreed. Hence, we can infer that most people believe that AI/MLis less biased.

Q.8. I think AI/ML technology is capable of solving complex problems in the area of Demand Forecasting which is beyond the capacities of humans



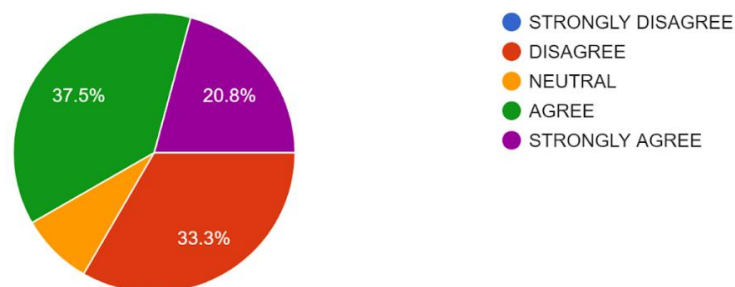
When the respondents were asked about their belief that AI/ML has capability to solving the complex problems, majority of respondents-45.8%, agreed with the statement while 37.5% replied with ‘strongly agreed’ with the statement indicating - most respondents believe that AI / ML will be able to solve complex problems. Whereas only 12.5% were neutral and 4.2% disagreed with the statement. Hence, from the above results we can infer that the majority of people believe that AI and ML are going to remove every hindrance by its ability to deal with complex problems.

Q.9. I think AI/ML technology makes less errors than humans in Demand Forecasting



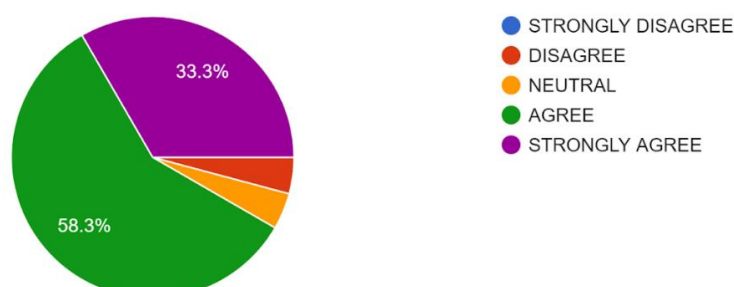
When the respondents were asked about their belief that AI/ML makes less errors than humans, majority of respondents, 58.3% agreed, 33.3% had strongly agreed with 4.25% reacting neutrally and also disagreeing to it. Hence, we can infer that most people feel satisfied about AI/ML making less errors as compared to humans. The statement indicates the strong belief people have in AI/ML.

Q.10. I think AI/ML technology is capable of work independently in the area of Demand Forecasting



When the respondents were asked about their belief that AI/ML is capable of working independently in tourism demand forecasting, majority of respondents 37.5% agreed, 20.8% strongly agreed with 33.3% also disagreeing. We also have 8.3% reacting neutrally. So statement indicates about the strong mixed opinion we had about AI/ML having independently and hence we can infer fear with confidence also being there inculcated the people.

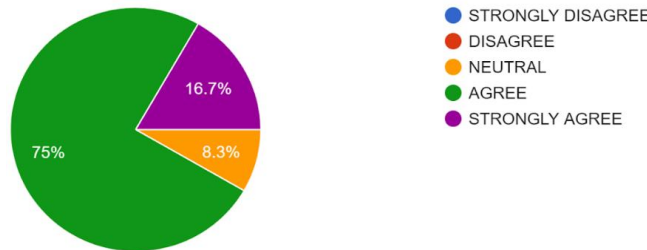
Q.11. I think AI/ML technology should work in supervision of humans in the area of Demand Forecasting



When the respondents were asked about their belief that AI/ML should work in supervision, the majority of respondents- 58.3%, agreed with the statement while 33.3% replied with ‘strongly agreed’ with the statement

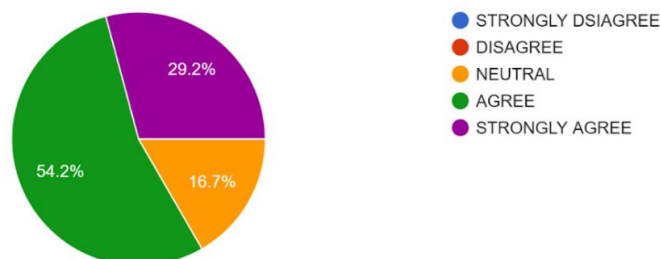
indicating - most respondents believe that AI / ML should work under supervision. Whereas only 4.2% were neutral and disagreed with the statement. Hence, from the above results we can infer that the majority of people believe that AI and ML can lead to betterment and enhancement by working under supervision.

Q.12. I think Employee resistance due to fear of job loss is one of the major hurdle in AI/ML technology



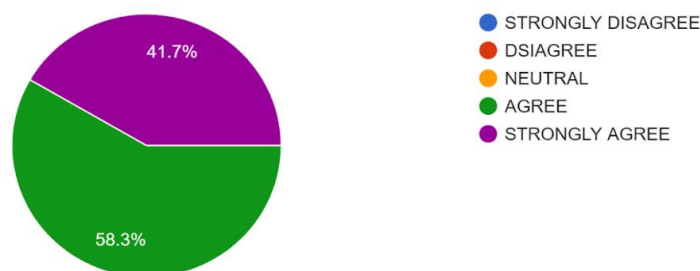
When the respondents were asked about their belief about employee resistance due to job loss as hurdle of AI, 75% agreed with 16.7% respondents strongly agreeing to it. In addition, 8.3% reacted neutrally indicating about the respondents possessing fear of unemployment and job loss. Hence, we can infer that to overcome the negatives AI/ML job loss is the bigger one.

Q.13 I think AI/ML technology is more time and cost effective than humans in Demand Forecasting



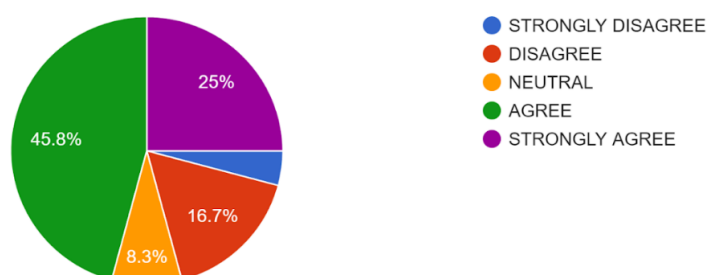
When the respondents were asked about their belief about AI/ML being more time and cost effective than humans, 54.2% respondents agreed while 29.2% strongly agreed. 16.7% were neutral towards the statement indicating that in reality, AI/ML has feature of being more time and cost effective and hence the result inferred is positive.

Q.14 I think AI/ML technology is able to handle large databases and numerous variables than humans



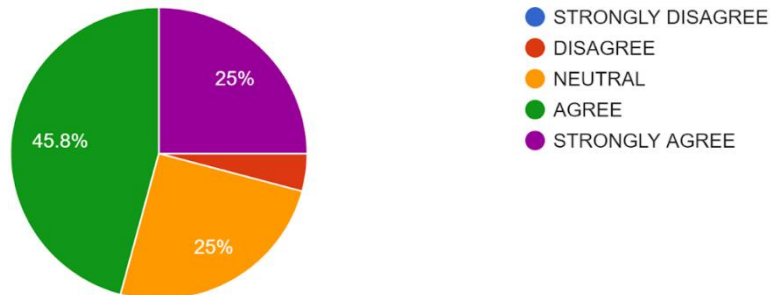
When the respondents were asked about their belief about ability to handle large databases and numerous variables than humans, 58.3% agreed and 41.7% strongly agreed. So hence the result that can be inferred that respondents strongly believe about the advantage of AI/ML in managing the databases and numerous variables effectively and efficiently.

Q.15. I think Complex nature of AI/ML technology is one of the major hurdle in its applications in Demand Forecasting



When the respondents were asked about their belief whether complex nature is one of its hurdle 45.8% respondents agreed, 25% strongly agreed 16.7% also disagreed with 8.3% being neutral. Statement indicate the majority of the respondents agreeing it to be a hurdle though there are many oppositions as well. Hence, the result inferred is that indeed it's a hurdle to be overcome.

Q.16. I think Non-transparent attributes of AI/ML technology is one of the major hurdle in its applications in Demand Forecasting



When the respondents were asked about if being non-transparent was one of the hurdles for the AI/ML, 45.8% respondents agreed, 25% strongly agreed and also reacted neutrally. Statement hence indicates it to be another hurdle and hence result inferred is it also to be overcome to have better development in application of AI/ML's advantages.

CONCLUSION AND RECOMMENDATIONS

Overall, the study concludes the following opinion and attitude towards demand forecasting applications of AI and ML in Travel and Hospitality industry:

1. Majority of industry experts and managers believe that AI and ML will improve their personal and professional life.
2. Most of the respondents were positive about the role of AI and ML in general and do not consider these technologies as threat to humankind.
3. Most of the managers strongly believe that there are numerous application advantages of AI/ML in demand forecasting.
4. Almost all respondents agree to the fact that AI and ML can perform better than humans and is capable of solving complex problems which is beyond the capacities of humans.
5. Experts and Managers strongly opined that AI and ML is capable of working independently with less cost and resources on large datasets.
6. However, Most managers and experts were of opinion that AI and ML should work under human supervision due to less transparency, fear of employee resistance (due to job loss) and complexity.
7. They also believe that the Non-transparent attributes of AI and ML technologies is one of the major hurdle of their slow applications in Demand Forecasting within Travel and Hospitality industry.

Therefore, with these insights from the primary data, we may conclude that AI and ML have very bright prospects of their applications in demand forecasting within Travel and Hospitality industry but most of organisations are going slow on applications due to Non-transparent attributes and fear of job loss.

LIMITATIONS

The biggest limitation of the study was the small size of respondents which might not have captured opinions of a large number of respondents due to selective sampling of industry experts and managers within Travel and Hospitality industry.

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