Study on the Influence of Deep Learning and Artificial Intelligence on Transportation and Mobility Industry and Corporations

Lixiao Liu

University of Manchester

E-mail: 1280538273@qq.com

Abstract. This article explores the affect that the rise of AI-based algorithms brought to the whole transportation and mobility industry. Since this industry has such many brunches, this article mainly focuses on taxi/ car-sharing segment. By researching the related journal and documents and using Uber as a case study, we can conclude that more and more AI-based algorithms will be adopted in the industry and benefit both of the society and the corporations within the industry. However, at the same time, the lack of data and experts resources can be obstacles.

Keywords: machine learning (ML), artificial intelligence (AI), transportation and mobility industry, taxi/ car-sharing

1 Introduction

Nowadays, data are everywhere and there is a trend of digitization in modern business world. As technology advanced, machine learning (ML) and artificial intelligence (AI) emerged and were applied in many industries such as retail industry and education industry. The application of these technologies begins to take over many functions in the firm including pricing, recruitment, demand prediction, defaultrisk prediction and so on. In this essay, we will use transportation and mobility industry as an example to explore how the rise of AI-based algorithms restructurethe industry and the corporations within the industry. Transportation and mobility industry is large and contains several branches, but we will only focus on a few of them.

At the beginning, we will have a brief introduction on ML and AI revolution. Then some application of ML and AI to the transportation and mobility industry will be shown. After that, the restructure that ML and AI have made on the industry and the firms within the industry will be discussed.

V. Escudero et al. (Eds.): BADS 2022, AHCS 11, pp. 1191–1199, 2023.
https://doi.org/10.2991/978-94-6463-102-9_123

2 The AI Revolution: A General Purpose Technology

Machine learning (ML) is a prediction technology and a general purpose tool which can be used in many industries since prediction is everywhere in today's world. Machine learning has actually been around for decades or you could argue centuries. Dating back to the 17th century, Bayes, Laplace's derivation of least squares, and Markov chains form a widely used tool and foundation for machine learning. In 1950 (Alan. Turing proposed building a learning machine) By the early 2000s (with practical applications of deep learning and more recent advances such as AlexNet in 2012), machine learning had advanced considerably.

Machine learning is a common research hotspot in the field of artificial intelligence and pattern recognition. Its theories and methods have been widely used to solve complex problems in engineering applications and scientific fields. The 2010 Turing Award was awarded to Professor Leslie Vlliant of Harvard University for his work on the theory of Probably Approximate Correct (PAC) learning. The 2011 winner of the Turing Prize was Professor Judea Pearll of the University of California, Los Angeles, for his contribution to the development of artificial intelligence methods based on probability and statistics. All these research achievements have contributed to the development and prosperity of machine learning. [2]

Machine learning is a science that studies how to use computers to simulate or realize human learning activities. It is one of the most intelligent and cutting-edge research fields in artificial intelligence. Since the 1980s, machine learning, as a way to realize artificial intelligence, has aroused wide interest in the field of artificial intelligence. Especially in the last decade, the research work in the field of machine learning has developed rapidly, and it has become one of the important topics of artificial intelligence. Machine learning is not only used in knowledge-based systems, but also in many fields such as natural language understanding, non-monotonic reasoning, machine vision, pattern recognition and so on. Whether a system is capable of learning has become a sign of "intelligence". The research of machine learning is mainly divided into two research directions: the first is the research of traditional machine learning, which mainly studies the learning mechanism and focuses on exploring the learning mechanism of simulated human; The second category is the research on machine learning in the environment of big data. This kind of research mainly studies how to effectively use information and focuses on obtaining hidden, effective and understandable knowledge from huge amounts of data. [2]

Machine learning after 70 years of tortuous development, represented by deep learning from the brain more layered structure, neurons connected interactive information analysis processing mechanism step by step, the adaptive and self-learning ability of powerful parallel information processing, harvest the breakthrough in many ways, is one of the most representative image recognition field.

There are mainly 4 types of ML which are (1) unsupervised learning, in which training data are provided without desired outputs; (2) supervised learning, in which both of training data and desired outputs are given; (3) semi-supervise learning, in which training data are provided with a certain amount of desired outputs; and (4) reinforcement learning, in which the machine will be rewarded for the accurate output and modified

for the inaccurate outputs to improve accuracy over time. Many businesses use ML to help with their corporation. For example, clustering is used to group customer comments to help the business to improve customer satisfaction, classification is used to analyze vast amount of customer profile data to design personalized products/service, and prediction is used to detect market signal and predict future trends in the market.

When different ML algorithms are combined together in different ways to build different systems that can be used for different purposes, an artificial intelligence (AI) system is emerged. In other word, AI is a system with modular nature built onmultiple ML algorithms and can be used to provide forecast of variable of interest from available data (Agrawal, Gans and Goldfarb, 2018). One of the features of AI is reinforcement learning, the capability to learn from mistakes and improve over time. After AI predicted certain things, the system will observe the empirical validity of thatprediction, make it a new piece of data and then absorb it to update the prediction capability. Besides the capability to get better over time, AI can be used in many industries since nowadays prediction is everywhere and can also make it easier to invent and produce new products. Therefore, AI is not only a prediction technology but also a general purpose technology.

Nowadays, there are some debates on the boundaries of ML and AI. Before talking about the conclusion of the argument, we need to understand the relations between decision, judgement and predictions first. Judgement is the capability to consider a decision which requires the understanding of situations. The difference between prediction and judgement is that prediction provides knowledge of the underlying state while judgement is the process of determining the payoffs from actions that arise based on the state. Judgement therefore allows decision makers to know which action is optimal for the given state. According to Agrawal, Gans and Goldfarb (2018), research found that judgment and predictions are generally complements if judgement is not too difficult and better judgement can improve the accuracy of prediction. This means that, generally, both of prediction and judgement are required in the decision making process. Therefore, we can conclude that the boundaries of ML and the AI system are not precise but are defined by data availability. Data availability is about whether you have data on the context within which decisions are made and data on the decisions made on those context. In other word, ML and AI can automate prediction while they cannot automate decisions if there is no enough data regarding judgment.

Artificial intelligence has been paid more and more attention in the field of computer. And in the robot, economic and political decision-making, control system, simulation system has been applied.

Professor Nelson defines AI as "the discipline of knowledge -- the science of how to represent knowledge and how to obtain and use it." And another US Massachusetts Institute of Technology professor Winston said: "Artificial intelligence is to study how to make computers to do the past only human can do intelligent work." These statements reflect the basic ideas and contents of the artificial intelligence discipline. That is, artificial intelligence is the basic theory, method and technology of studying the law of human intelligent activities, constructing artificial systems with certain intelligence,

and studying how to make the computer complete the work that requires human intelligence to be competent in the past, that is, studying how to apply computer hardware and software to simulate some intelligent behaviors of human beings.

Artificial intelligence is a branch of computer science. Since the 1970s, it has been known as one of the world's three cutting-edge technologies (space technology, energy technology, artificial intelligence). It is considered to be one of the three cutting-edge technologies of the 21st century (genetic engineering, nanoscience, and artificial intelligence). This is because of its rapid development in the past 30 years, has been widely used in many disciplines, and has achieved fruitful results, artificial intelligence has gradually become an independent branch, both in theory and practice has become a system of its own.

Artificial intelligence is the study of computer to simulate some thinking process and intelligent behavior of human (such as learning, reasoning, thinking, planning, etc.), mainly including the principle of computer to realize intelligence, the manufacture of computers similar to human brain intelligence, so that computers can achieve higher level of application. AI will involve disciplines such as computer science, psychology, philosophy and linguistics. It can be said that it is almost all the disciplines of natural science and social science, and its scope has far exceeded the scope of computer science. The relationship between artificial intelligence and thinking science is the relationship between practice and theory, and artificial intelligence is in the level of technical application of thinking science, which is an application branch of it. From the point of view of thinking, artificial intelligence is not only limited to logical thinking, to consider the image thinking, inspiration thinking can promote the development of the breakthrough of artificial intelligence, mathematical basic science often considered a variety of disciplines, mathematics is also entered the language, thinking, the artificial intelligence subject must also use mathematical tools, mathematics is not only in the standard scope of logic, fuzzy mathematics and other work, Mathematics enters the discipline of artificial intelligence, they will promote each other and develop faster. [6]

3 Applications of AI and ML to Transportation and Mobility Industry

Human cannot live without transportation and transportation has been the fourth largest household expenditure category in the UK with an average of £354 per month(Figure 1) (Erin Yurday, 2022). However, due to the fast-growing population and outdated systems, modern cities have inherited several problems including: (1) congestion, which costs a lot of time and money, (2) inefficiencies, which is due to the delay and cancellation of journey, and (3) sustainability, as transportation is one of the biggest contributor of greenhouse gas emission (Aalto Capital, 2020).

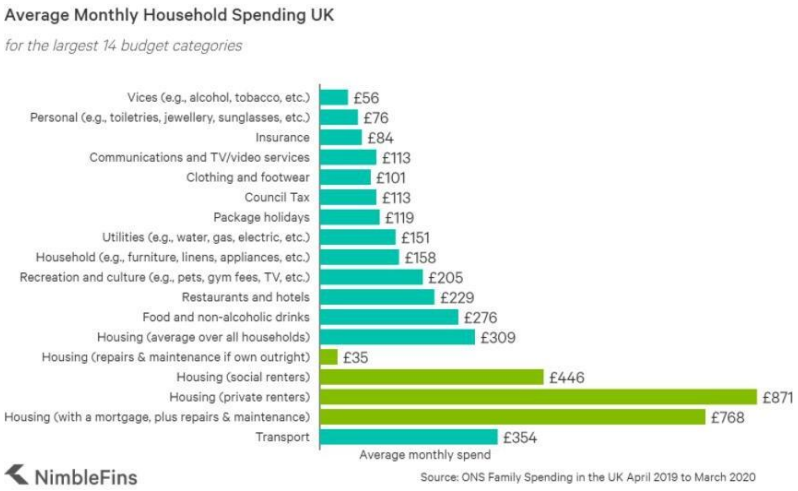

Fig. 1. Average Monthly Household Spending UK

To resolve the problems, a concept called smart city, which aims to use data and different types of technologies to improve sustainability, create economic development and enhance quality of life in the city, is introduced. For example, ItoWorld, a UK company making transit data manageable by standardizing and quality-checking the data,is one of the famous companies working on smart cities.

Ito World aggregates transit data into a single-city feed called Transit Hub. And then machine learning algorithms and experts ingest the transit data to predict the bestroutes and update the journey arrival time based on similar historical cases at the same time. This can help the passengers to plan journey and avoid congestion therefore improve efficiency of transportation in the city (Aalto Capital, 2020).

Similarly, another concept solution called Mobility as a Service (MaaS) was also introduced, which can take into account, for example, congestion, air quality, better customer experience and so on. MaaS is a consumer centric transport as a service model that matches a mobility solution to an individual consumer's need by using MLand AI. In general, according to the MaaS concept, the supply side of transportation in terms of planning, booking, ticketing and payment are integrated with consumer'sneed as one product via a platform (Bower and Wex, 2018).

Other applications in the industry are driverless vehicles, Uber is one of the firms that invest in this field. Uber also uses AI and ML to predict price, find optimal routes for drivers, respond to support issues in natural language, detecting potential defaults, updating knowledge of changing roads and so on. For example, Uber's estimated time of arrival (ETA) system using ML to provide ETA on pickups and arrivals which are critical to positive user experiences, and Uber's customer support generate better satisfaction rating by using ML models which speed up handling timeby 10%. These further provide Uber with more competitive edges.

4 Business Models, Competition and Growth Strategies in the Industry

Transportation and mobility industry is a big industry containing many branches. To make it easier to explore the affect of AI-based algorithms on the industry, in this essay, we will mainly focus on the taxi/ car-sharing segment of the industry.

Before the rise of data and ML/AI technologies, the business models used in taxi sector of the transportation and mobility industry are virtually the same as the ones that were used when coachmen operated the service with a horse and a carriage (Darbéra, 2017): "the operator owns a vehicle fleet driven by chauffeurs who deliver the door-to-door mobility service to customers for a fee" (Merijn, Oktay and Onat, 2022).

However, the business model changed in 2009 when Uber introduced the concept of e-hailing into the market and disrupted the taxi market by the advantages of platform-based business models (Walji and Walji, 2016). With the platform-based business model, taxi drivers and passengers can be matched directly through the third-party platform provided by a e-hailing service provider. At the same time,because of the popularity of smartphones, geo-locations can be used by both customers and drivers, enabling the match of supply and demand much more efficiently. Moreover, other competitive advantages of using advanced technology include (1) better adoption to fluctuating demand as labor are flexible, (2) less cost on equipment as there is no need to purchase things such as taxi meter and rooftop sign, (3) the service can be dispatched in a cheaper and faster way, and (4) the optimization with algorithms is more efficient and can provide more suitable surge pricing compared to manual optimization (Merijn, Oktay and Onat, 2022). Hence Uber grows rapidly and has become available in more than 10,000 cities (Uber,2022).

After seeing the success of Uber, companies such as Lyft, Grab and Cabify quickly launched similar service to generate a share in the market (Merijn, Oktay and Onat, 2022). Although the service provided by the firms are similar, some of them use different models. For instance, Cabify accept various forms of taxi services provided by drivers with VCT license, freelancers and regular cab drivers and Gett focuses on offering customers with tailored traveling policies such as specifying allowed vehicle types and limiting distance (Merijn, Oktay and Onat, 2022). Since that, the taxi market can be seen as a monopolistic market.

In the monopolistic market, the core business strategy is continuous product differentiation through marketing, branding, R&D and quality. The monopolistic competitive firms in the market will earn profit at early stage because the price will exceed the marginal cost (MC) (Figure 2). This gives some explanation on the rapid growth of companies such as Uber as more profits provides the firm with more competitive advantages: the firm can generate more money to invest into product differentiation and therefore to grow faster. Investment in AI is crucial in this market because AI can improve the efficiency therefore the competitiveness of the firm, and those who fails to do so will lose their market shares.

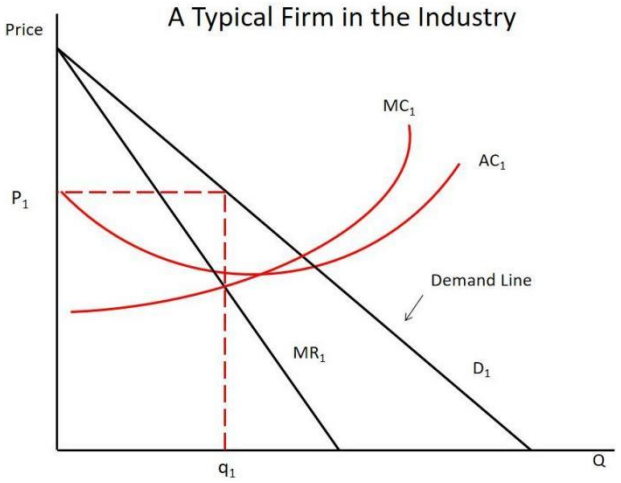

Fig. 2. Price, Demand and Marginal Cost of a Typical Monopolistic Competitive Firm in the Market

To develop further, Uber has launched its Uber AI Labs which aims to use AI and ML to make consumers' ride more efficient and better value. Uber's AI ambition is using AI to transform urban transport and so Uber acquired an AI and ML start-up Geometric Intelligence to create new divisions (Verdict AI, 2018). With these investment, further into the future, Uber could make visions of self-driving cars, urban aviation and optimized cities a reality (Verdict AI, 2018).

5 The Internal Organisation of the Firm i.e Uber

We will continue using Uber as an example. Uber uses various forecasting predictions to make data-driven decisions at scale including (1)marketplace forecasting, predicting user supply and demand to direct drivers to high demand areas before thehigh demand occurs, (2)hardware capacity planning, to avoid under-provision or over-provision which are costing, and (3)marketing, estimating marginal effectiveness of different media channels while controlling for trends, seasonality and other dynamics such as competition and pricing (Robinson, 2019).

After seeing increasing ML deployments, Uber has grown its ML staff to hundreds of data scientist, engineers, product managers and researchers in just a few years. Unfortunately, facing the widely varying requirements for ML problems, there is still shortage of expert resources. To solve the scarcity of expert resources, some of Uber's key teams work together to design, build, and deploy new ML systems in production. Each of the product engineering teams at Uber owns the model they build and deploy in production. These teams are staffed with the full set of skills they need and, depending on the complexity of the ML solution, sometimes can get assistance from specialist team to address the additional expertise they cannot handle. The specialist teams have deep expertise across various fields such as natural language processing, forecasting

and others. And another team called machine learning platform teams are responsible for building and operating a general purpose ML workflow and tool set which are used by product engineering teams.

Uber also introduced its advanced ML platform, Michelangelo, consisting of a mix of open source systems and components built in house. To make a ML platform that canscale up, Uber also makes sure to get the most important technical considerations correct including the end-to-end ML workflow, treating ML as software engineering, model development velocity and maintaining a modular and tiered architecture (Robinson, 2019).

6 Conclusion

To conclude, AI and ML have disrupted the transportation and mobility industry and helped them to transform to a new form that can benefit not only consumers but also the whole society. With the development of smart cities and MaaS concepts, more AI and ML will be adopted and technology used in the industry will be advanced. However, the limitation may be the hungry of data and scarcity of expert resources as these are still quite new concepts waiting to be explored.

References

1. Aalto Capital (2020). Big Data Transforming the Transport Sector. Available at: https://aaltocapital.com/wp-content/uploads/2020/07/Aalto-Capital-Big-Data-in-Tra nsport.pdf (Accessed: 21 April 2022).
2. Agrawal, A., Gans, J. and Goldfarb, A. (2018). *Prediction machines: the simple economics of artificial intelligence*. Boston, Massachusetts: Harvard Business Review Press.
3. Bower, J. and Wex, S. (2018). Mobility as a service: what is it and where is it going?. Availableat: https://www.womblebonddickinson.com/uk/insights/articles-and-briefings/mobility-service-what-it-and-where-it-going (Accessed: 21 April 2022).
4. Darbéra, R. (2017). 'Business--models for the taxi of the future', *International Road Union (IRU)*. Available at: https://hal.archives-ouvertes.fr/hal-01631663 (Accessed: 21 April 2022).
5. Erin Yurday (2022). *Average UK HouseholdBudget 2021*. Available at:https://www.nimblefins.co.uk/average-uk-household-budget#nogo (Accessed: 21 April 2022).
6. Lee, I. and Shin, Y.J. (2020). Machine learning for enterprises: Applications, algorithm
7. selection, and challenges. *Business horizons*, 63(2), pp.157–170.
8. Merijn, B., Oktay, T. and Onat, E.A. (2022). 'A Review of Business Models for Shared Mobility and Mobility-as-a-Service (MaaS): A Research Report'. Available at: doi:10.13140/RG.2.2.27170.35524 (Accessed: 21 April 2022).
9. Robinson, J. (2019). *How Uber Organizes Around Machine Learning*. Available at: https://jamal-robinson.medium.com/how-uber-organizes-around-artificial-intelligen ce-machine-learning-665cdeb946bc (Accessed: 21 April 2022).
10. Uber(2022). *Use Uber in cities around the world*. Available at: https://www.uber.com/global/en/cities/ (Accessed: 21 April 2022).

11. Walji, J. M. and Walji, W. (2016). 'Uber, a disruptive business model of a taxi service', *International Journal of Systematic Innovation*, 4(2). Available at: doi: https://doi.org/10.6977/IJoSI.201610_4(2).0003 (Accessed: 21 April 2022).