APPLICATION OF MULTI-AGENT SYSTEMS FOR THE DEVELOPMENT OF INTELLIGENT TRANSPORT SYSTEM

Abstract

In this chapter, research is provided on agent-based approaches to transportation. As there is a new era in IT (Information technology), the MAT (multi-agent technique) could help for the reaction towards the increasing interest which is making transportation and traffic more functional. The main aim of transportation and traffic systems is the best which suits an agent-based approach as transportation systems are distributed geographically in the dynamic changing environment. In this, the methods and techniques are found resulting from the fields of both multi-agent and agent systems which have been appealing to many features of transportation and traffic systems, that also includes testing and modeling, and managing of intellectual traffic control. The main feature of the MAS (multi-agent system) is independency, convolution, resilience, and motility can always resolve their contributions. Ultimately, many research directions about the successful distribution of multi-agent technology in transportation and traffic systems are talked through.

Keywords: multi-agent systems, smart cities, intelligent transportation, traffic, modeling and simulation.

Authors

Giri Sathvika Vairam
Btech Ⅱ year Student
CSE AI&ML Department
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

Adivishnu Sri Sai Keerthi
Btech Ⅱ year Student
CSE AI&ML Department
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

Jashwitha Ganapathiraju
Btech Ⅱ year Student
CSE AI&ML Department
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

Srujana Pynni
Btech Ⅱ year Student
CSE AI&ML Department,
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

Apoorva Vanumu
Btech Ⅱ year Student
CSE AI&ML Department
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

Geetha Usha Sri Bade
Btech Ⅱ year Student
CSE AI&ML Department,
Pragati Engineering College(A)
Surampalem, Andhra Pradesh, India.

I. INTRODUCTION

Prefatory Concepts

The development of intelligent system is classified into two sub groups. They are Multi Agent System and Shared Transport Services. In the preliminary concepts, we will be discussing briefly about both of these topics. To get to know about the surrounding atmosphere with the act of sensors by a respective agent, it is predominantly achieved by the servomotor. In the multi agent system, the representatives make their own individuality. They do not depend on the other agents working with the order of their preference. To add more, they aim to achieve more potential which brings to the strength to practice through required knowledge and expertise. Since every agent have their independency, none of them actually rely on each other assignment. Inclusively, they wrap around by fraternizing alliance. This alliance associate in growing a proper system. These multi agent systems accord the perfect meaning to collaborate dominance and carry out a skill. The inheritance of MAS permits informative sum of features to be processed. By increasing the number of agents and their practices, the multi agent system can be extended, thus realising the content of the surrounding environment.

II. METHODOLOGICAL APPROACH

The methodological approach aims on the structural work of the writings which deals with the stage of recognition and survey of the required work. This marks the main concept of the subject and allows the correct way of approach. The method of approaching and processing will provide the overall plan, types, studies, and the origin of a system. An orderly plan about the literature conveys a technique for the growth of a well defined and organized ways to receive the outcome based on a source called bibliographic reference. With this complication, there will be a clear objective on the advantages of MAS to shared transport service. To point the bibliographic design of study in various sources and rectify their preliminary and methodological applications in the required concerns, it is necessary to understand and examine the process. After scanning the service, we then organize the data in a way that fits into the system. The concord we define should implement the real world entities and their solutions. This encourages the development of massive contributions to literature. The important constituents of methodology are as follows:

- Key elements of the theme
- Analysis
- Purpose and Target
- Survey
- Meaning of bibliographic design
- Assessment of study
- Synopsis
- Demonstration of outcome

III. STUDY OF OUTCOME

This stage provides the solution for the three main queries:

How are the shared transport services marked as multi agent system?

Since the agents are individualistic which strives them to achieve the answer to all the effects of the issue, MAS aim to rectify the required complications such as: development, interaction, configuration, task dissension and allotment of work to be processed.

What are the constraints in the shared transport services that influence the performance of MAS?

The primary limitation of MAS in shared transport service is its commodity of services, privacy insecurity and the contemplation of previous approval for both passengers and drivers. This challenges MAS to compete in real world system. In addition to this, modules regarding real time operation can be addresses. The approach of dynamic system emphasize the necessity of service which brings the implementation for MAS development.

In what way is the execution of shared transport service presented?

As mentioned in the preliminary phase, the studies utilize various standard system prototype. They are in fact the most essential purpose of the studies. The evaluation of this system is crucial at this point since it triggers the overall growth of the study. Calculation of the path between the passenger and the driver is taken into consideration. The financial cost of the trips is examined. The time execution of the algorithms and re-scheduling of the routes are also the steps involved in the execution of the performance of this service. The assessment and the division of the service are also directed to the studies. On online platforms, various tasks like driver categorization and carpooling are considered in real world.

IV. BACKGROUND STUDY

In the last few years, Intelligence Agents and more recently, Multi-Agent Systems appeared as new software technologies. Due to these new software strategies, a part of statistical functions in particular facilities are at a proper and fixed location is widespread. Many changes in spatial movements of goods between shipments of origin-to-destination and flow model estimate O-D flow are achieved at the depot, the admeasurement of location tips referred to as “Masterminding Manifesto”. It is possible to find the needs of chains using these physical infrastructures. It can be mentioned more significantly, as follows: Visibility(detecting, tracing, and tracking); Picking and Packing; Demotic and Robotized warehousing and factoring; Modularization and Postponement operations; Operations escalation: Efficient handling; Real-time management of transportation; interactiveness and multimodality; Escalation of transshipment and cross-docking operations; Diminishing of ohmage; coactions of suppliers network; Spatiotemporal abbreviation; methodical energy usage; sequence tracking and management; Screenwork comparability; Concurrent statistics splitting. The above given few factors are the main factors that act as important aspects in Intelligent Transport Systems.

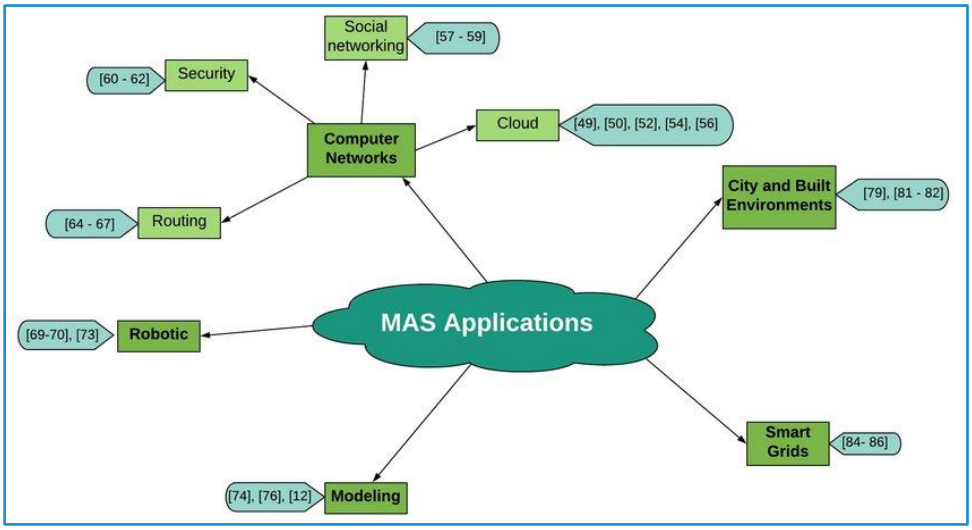
As a new era in Information technology, multi-agent technology can help to respond to the growing interest in making traffic and transportation much better. What we dearth are few software models or connections between the methodology and the sub-methodologies of software to make a particular place a well-known place like a smart city. Being a smart city does not mean that the city consists of buildings etc… but also in general that place should contain some portrayal linkage of discrete subsystems that should work without depending on the other systems and in the same way it should work by sharing the data that could help the exceptional operation of these subsectors within the smart city. To make the city like a smart city we should start with designing the systems with interrelationships.

Due to this cause, we are insisting on using Multi-Agent Systems as the main tool for customizing the interrelationship between the systems. Each and every consequence can be geared as an intelligent aspect with its properties, animus, and its preferences. So by knowing the above aspects we can easily interlink the systems to make the city a smart city using the links among the solitary unconventionally in vigorous patterns because the Multi-Agent System does not represent only immobile resolution. citizens, as well as systems, should work with an exclusive of and with better stability.

However, Multi-agent Systems are a well-known abstraction tool and this system will be helpful in different domains. The potential of Multi-Agent Systems in the Transportation domain consists of the attributes for which the Ahead-Of-Time has been progressed and focused. Transportation Management quietly depends upon the tessellations, implementations, and others to modalize the transportation rules for better financial and eco-friendly nature. Of increasing the significance of transportation in transportation management is the amalgamation and interrelation of different transportation means. Interconnecting or Interrelating the systems is very difficult to handle because those systems consist of several applications that are antithetical. It is very important to steadiness the aim of the system and to make certain the conjugate of distinct systems will convene to enhance the quality of survival of the people.

Multi-agent systems are a specific type of intelligent structure in which independent envoys occupy the world globally. The main aspect of a multi-agent system is independency, convolution (Having a clear idea about his\her deeds (like decision making, and thinking rationally), resilience (accommodating sudden changes), motility, unanimity, and forthrightness (Multi-Agent Systems (MAS) can always resolve on their contributions. In multi-agent systems, agents will merely outlook the local views. This system consists of both minimalist and inoperable effects.

Figure 1: Depicts the MAS Applications [6]



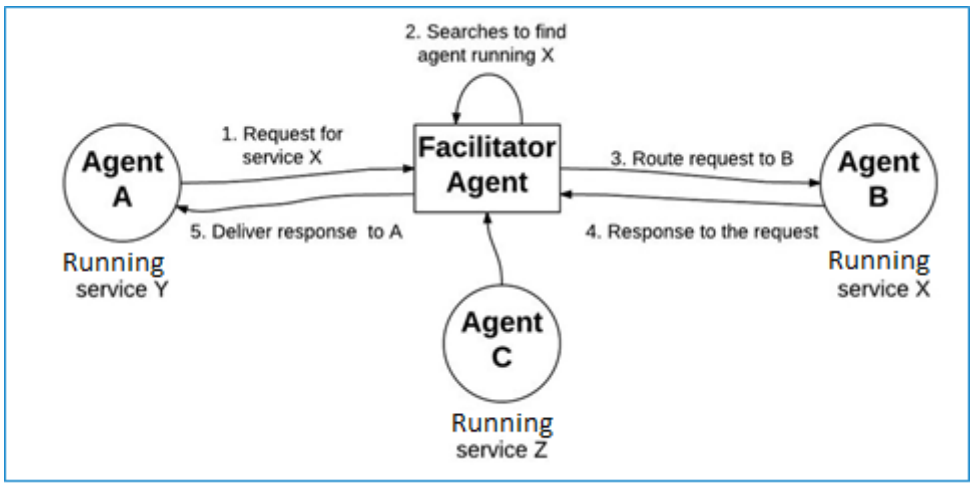


Figure 2: Depicts the Working of Multiple Intelligent Agents

V. CURRENT TRENDS IN INTELLIGENT TRANSPORT SYSTEMS

Technologies now can handle the present-day urban traffic which is highly impacting the transport system in smart cities. Along with the traffic, issues like vehicle-pedestrian accidents, car parking space, route recommendations, pollution, congestion, automated traffic lights, and waiting of vehicles, everything is dealt with by multi-agent systems along with other high-end technologies. Multi-Agent systems [MAS] stand as a solution, by approaching this problem using datasets and forecasting usual transport patterns, with much less effort and human involvement. Recent studies show a lot of development in intelligent transport systems among smart cities. A few of them are discussed below.

1. **Multi-agent systems for intelligent urban traffic management:** Regarding the Multi-Agent System applications, Maria Viorela Muntean [1] proposed the idea of using wireless sensor networks data and real-time traffic patterns from the Birmingham council

to develop a model which is efficient to tackle the traffic. Their article proposed an approach using a multi-agent system [MAS] for intelligent urban traffic management in the city of Birmingham using classification and forecasting techniques. The intelligent agents are designed such that they perform the following tasks: forecast the occupancy rate for car parking, traffic jams in a particular area, and road junctions; distinguish the faults; control and inspect the entire procedure. A monitoring agent is used to coordinate this whole process of learning and manage the traffic of Birmingham city. For performing forecasting and classification operations on the obtained datasets, WEKA, a data mining tool was used. The various multi-agents used are the Road junction agent, Car parking agent, Fault Detection agent, Traffic flow agent, and Monitoring agent by which all these agents are connected and automated.

The Framework used to implement the MAS was Java Agent Development (JADE). This aids the communication among multiple agents and makes use of the Foundation for Intelligent Physical Agents and Agent Communication Language (FIPA-ACL language). The designed agents were implemented in the Main JADE Container from the agent platform. All the sent and received messages and performed tasks were shown in the application output. The discovered patterns and the forecasted data are received by the monitoring agent and it can exhibit various operations to optimize urban traffic management and control.

2. **Multi-agent systems for dynamic transport:** The research at Prague by Patrik HORAŽĎOVSKÝ, Sergey KOZHEVNIKOV, and Miroslav SVÍTEK [2] was done with an idea that better public transportation can be obtained only with a great number of satisfied customers. This can be achieved by understanding the transport patterns or routes that passengers are most likely to attract and the demands of passengers. As a result of that, they proposed a paper with the major task to construct dynamic routes based on a mentioned graph for mentioned values of the criteria of consistency (i.e allowability) of the acquired solutions. The perspective of this problem doesn't allow to get a single exact solution in an ample amount of time. Using the MAS approach they created a sensible solution which can also be called a "quasi-optimal" coordinated (which is widely accepted) solution that reflects the balance of choices between all agents in the process of decision making.

   The multiple intelligent agents used are The Agents of people, which pay transportation charges and can seek multiple routes. Agents of routes design multiple routes for passengers and choose a type of vehicle basing on the required area for a particular number of people. Fleet agents transport passengers and pay the operation price (fuel, driver´s pay, et cetera.). Thus they achieved the goal of dynamic public transport using MAS.

3. **Pedestrian safety:** Pedestrian safety is the biggest concern in smart cities. The unsignalized zebra-crossing stood as one of the major causes of an increasing number of traffic accident victims. To overcome this problem, Byeongjoon Noh gave an advanced model for potential pedestrian risky event (PPRE) analysis by collecting the video footage from the security cams installed at that type of crosswalks which are not installed with proper signals. That system automatically identifies vehicles along with their speed and pedestrians along with their respective speeds, calculates path trajectories, and extracts

frame-level behavioral features. These events are classified into 6 clusters by making the use of k-means clustering and decision tree algorithms, then visualize and interpret these clusters to predict how they will contribute to pedestrian accidents and also to find out what can be the better solution to decrease accidents at the crosswalks. They successfully validated the sensibility of that model by applying it to video clips from the crosswalks in Osan city, South Korea, where the signals are not installed. Finally, they found out that pedestrian velocity, vehicle velocity, and vehicle-pedestrian distance play an important role in pedestrian accidents.

4. **An eco-friendly multimodal route guidance system using MAS:** Coordinating the various modes of transport has always been an unachievable goal. But when achieved, it benefits the total intelligent transport system. In the paper proposed by Abdallah Namoun [3], a distributed mechanism of an eco-friendly route guidance system has achieved this coordination by utilizing the agent-based model. That model used software agents to observe and represent the network of various transportation infrastructures of urban environments that include roads, traffic signals, bicycles, cars, metros, buses, trams, and pedestrians. That system makes use of live traffic data like density, traffic flow, and CO_2 emissions which are gathered from multiple data sources to come up with multimodal route recommendations for travellers through application software. Additionally, the proposed system allows the transport management authorities to keep track of the traffic patterns and environment of a city in real-time with the help of dedicated visualization on the web.

   They exhibited the advantages of using multiple agents to showcase the multifaceted nature of transport networks and realized the concept of smart transportation. A technical simulation was carried out at Nottingham in the United Kingdom and at Sofia in Bulgaria to exhibit the practicality and ease of use of the multimodal travel information system in postulating route guidance in an eco-friendly method.

5. **Electric vehicles and multi-agent systems:** Electric vehicles are introduced as a solution to the problem of pollution, congestion, and fossil fuel conservation. David Eneko Ruiz de Gauna [4] proposed an idea of a model which is a combination of electric vehicles and multi-model systems which would deal the congestion and pollution with much ease and in a minimum period. Like a well-oiled machine, this combo would work well.

6. **Agent-based cyber-physical systems architecture for smart parking systems:** Parking is the biggest problem faced by most people. People usually waste hours in search of parking space. In this context, Lucas Sakurada [5] proposed the smart parking system as an idea to avoid traffic congestion and long search hours for a parking place. The incorporation of blooming information and communication technologies and the techniques of artificial intelligence, especially making the use of multi-agent systems, amalgamated with the Cyber-Physical Systems (CPS), guarantee modularity, pliability, adaptability, and the decentralization of intelligence through dynamic and autonomous entities. These smart parking systems can be easily adapted to any vehicle variant to be parked and are functional with regard to the number of drivers or the number of vehicles and parking spots.

This model was implemented in two different parking regions. One is a bicycle parking system and the other is a car parking system. The model exhibited an efficient, adaptable, and modular operation.

7. **Traveller Assistance Decision Support Systems (TADSS):** TADSS is proposed by Krzysztof Modelewski in his article "Applications of multi-agent systems in transportation", which deals with traffic management by using different intelligent agents which work together by decentralization.

TADSS architecture is hierarchical (master-slave). They are classified into three types of agents:

- Traveller agent, which is responsible for obtaining requests from traveller for travelling and
- Sends the feedback to the traveller. This agent acts as a Human - Machine - Interface (HMI) between humans and software agents. This agent along with defining trip planning criteria also stores the proclivity of the traveller.
- Coordinating agent - coordinates the transportation agents, and recommends the finest route or change of mode by which the traveler is being transported. The coordinating agent calculates and optimizes the global goal depending on the data obtained from transportation agents. A map of existing transportation system is with this agent.
- Transportation agent- is accountable for receiving information from the traffic management services and other traveller systems of information to notify the coordinating agent about any fluctuation or deviation from normal and standard circumstances.

All the above-mentioned intelligent transport systems are still the beginning of the new era. One of the biggest benefits of the MAS approach is its high scalability, robustness, and flexibility according to the input given based on different environments. The agent-based approach is an excellent method for developing such systems with the prospect of appending new agents to the existing model and enhancing the required functionalities.

VI. FUTURE DIRECTIONS

AOT (AGENT ORIENTED TECHNIQUE) have been improved and so goaled at the traffic is geographically divided, subsystem has great degree of functionality and the applications of traffic play a vital role.

Traffic management system: The system of traffic management is mostly depends on the process of planning, development of traffic regulation aimed to reduce the traffic demands under features of economic and environment. The system of traffic management is the inter-relation of various traffic infrastructure. Information of ride, travel, reservation, driver routing guide, inter relation and fleet management are few examples for traffic management ways.

Analysing and describing traffic systems: AOT (AGENT ORIENTED TECHNIQUES) provides the objective measures for analysing, modelling and traffic system designing in

terms of its configuration, everything with it's specific local duties and their capacities. Collaboration could be resulted by modelling inter-relations between them.

Increasing the capacity of traffic components: The traffic centres advices and provides information unique to their site. These centres are inter-related, in several cases subsystems plays vital role. Usage of AOT acts as an agent with a required measure of autonomy such that subsystems have an active control on their decision having exact inter-relation among agents. They can cooperate with each other with aim to develop their performance, to accustom the traffic demand dynamics.

Road traffic: Several system components which are used in guidance of road traffic (for example modify traffic signs for the control of traffic flow on highways) can be made more autonomous if modelled as agents. The most dissatisfactory thing was the measure of evincing strength of the existing systems, this is because of fact that numerous possible network states might be larger in number, as a result it's less sensible in specifying the central plans. Achievement of new events lead to results to the quick change in the network state and as a result the traffic regulating plans will never be executed.

By using multi agent systems will lead to a huge evincing strength. Information regarding traffic flow can be triggered by local agents who controls the flow of traffic. If an event have results in control of the adjacent zones, the relative agents are told to adopt their plan. Such system has the benefit of the local modifications are being considered at local level and they are dealt immediately. The system can quickly react and accustomed to the new circumstances. With the increasing significance of environmental reasons in traffic, more routing of traffic systems can be envisioned. Those systems contain a network of interrelated stationary and mobile stations, electric vehicle power stations, centres of traffic routing. These type of systems could be designed as a MAS(multiagent system) where agents discuss and collaborate to decrease the environmental damage.

Simulation of Agent-Oriented-Traffic: With the rapid increase in the traffic persistently needs effective solution. So, the capability of the network of road should be multiplied through intellectual traffic flow. In mentioned concept of traffic designing and testing techniques are to be used in investigation and control plans alternatively. The simulation of traffic models are microscopic and macroscopic. The approach towards hydrodynamic traffic flow is suitable to macroscopic design. To observe the behaviour of every vehicle, microscopic simulations are essential. Both the driver and vehicle are collaboratively designed as driver-vehicle system. Every driver-vehicle system might be seen as an intellectual sub-system.

Improving the present systems by the capacities of agents, guide to a more requiring testing approach. From technical point of view, pros of agent oriented approach are:

- High-level of driver-vehicle description behaviour, this is simpler to modify, edit, maintain.
- Possibility for easy communication and coordination between the vehicles.

The above-mentioned agent oriented traffic simulation is a type of microscopic simulation.

The future: Skill of vehicles to interact and coordinate the design of new concepts of traffic simulation. For this reason, the sensors in addition should evaluate the position of the vehicle in traffic relation controls. As traffic lights are absent to control flow of traffic, this kind of simulation involve the design how drivers find the right moment for crossing the junction. The agents communicate to synchronize their actions. When the directions of two driving vehicles are at an angle 90 to each other and both of them are in same place for crossing the junction. We shall realize local traffic control plan without using control of hardware related to traffic light. Coordination of all the vehicles could develop necessary actions in traffic and rapidly raise the running of the vehicles. Through the enabling of vehicles for coordination and cooperation with each other, AOT (AGENT ORIENTED TECHNIQUES) provides techniques to improve new scenarios for the domain.

Developing the stations for carpooling: In improving applications for planning in organisation of traffic, a carpooling simulator platform is improved. Sharing of cars by customers will attract the users. The theme is the promotion of sharing cars by users might gain savings on costs of maintenance when a car is owned. Customers would request higher quality of service. The simulation of car pooling platform is gold at providing the experiment with various structures of organisation, fleet composition, technical requirement of cars of pooling stations. The goal is for reducing the running costs of the stations and provide an agreeable system for the benefits of the user.

The models of the system modify the car booking and management at stations. Each pooling station is given numerous cars. The simulation system uses investigations on customer commuting choices. They provide information such that the number of times cars have been used. Each agent provides its timetable. To acquire an aim to commute at a particular time to a particular destination with a particular car, it constantly monitors every customer timetable against the simulation clock, and also emits messages from time table agent to the customer.

It assists with records for cars and their schedules. On receiving requests, car pooling station agent finds its database, if the customer's choice could be fulfilled the requested car is booked for the customer.

The MAS is giving the best models in order to overcome many such problems and the extent of its applications is going to make the earth a better place to live in.

VII. CONCLUSION

In this chapter, we report our first attempts to identify the potential opportunities of a multi-agent system to support current and future works. Using this, important decisions can be made in a shorter time, improving citizens' lives. This article proves a simple example, of how the multi-agent system can help to resolve the solution of public transport service in a small village by dynamics. Multi-agent system can be a general mathematical tool for resolving transport services in the region. The paper presented the concept of dynamic Travel Assistance Decision support systems. One of the biggest benefits of the approach presented in this paper is scalability and flexibility. The agent-based approach is a natural method for the development of such systems. Additionally, we presented a comprehensive workflow from

model development to the analysis of results. GPU-based processing can be done for specific accelerations of environment moves and explore tasks. In cases of cloud-based execution, the run-time reduction will benefit from horizontal scalability of the SGE graph, which is still a hard problem in terms of graph databases. Future work includes enhancing the model with multi-model transport features and adaptive human behavior. The simulation results will be validated by field data obtained through public authorities and public transport organizations. Additionally, the presented approach will also be adapted the other cities.

REFERENCES

[1] Citation: Muntean, M.V. Multi-Agent System for Intelligent Urban Traffic Management Using Wireless Sensor Networks Data. Sensors 2022, 22, 208 https://doi.org/10.3390/s22010208
[2] P. HORAŽĎOVSKÝ, S. KOZHEVNIKOV and M. SVÍTEK, "Dynamic Public Transport in Smart City using Multi-agent system," 2019 Smart City Symposium Prague (SCSP), 2019, pp. 1-5, doi: 10.1109/SCSP.2019.8805716.
[3] Namoun, A.; Tufail, A.; Mehandjiev, N.; Alrehaili, A.; Akhlaghinia, J.; Peytchev, E. An Eco-Friendly Multimodal Route Guidance System for Urban Areas Using Multi-Agent Technology. *Appl. Sci.* **2021**, *11*, 2057
[4] De Gauna, D.E.R.; Villalonga, C.; Sanchez, L.E. Multi-agent systems in the field of urbane-mobility: A Systematic Review. *IEEE Lat. Am. Trans.* **2020**, *18*, 2186–2195
[5] Sakurada, L.; Barbosa, J.; Leitao, P.; Gleifer, A.; Borges, A.P.; Botelho, P. Development of Agent-Based CPS for Smart Parking Systems. In Proceedings of the IECON 2019—45th Annual Conference of the IEEE Industrial Electronics Society, Lisbon, Portugal, 14–17 October 2019; pp. 2964–2969
[6] https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.6148&rep=rep1&type=pdf

