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Faculty of Technical Sciences,
Bitola, Macedonia

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Dear Colleagues,

On behalf of the Technical Program Committee it is my pleasure to announce that the 57th International Scientific Conference on Information, Communication and Energy Systems and Technology ICEST 2022, which was held from 16 to 18 June at the Faculty of Tourism and Organizational Sciences - Ohrid, North Macedonia.

The ICEST Conference gained its acronym as a successor of EIST Conference in 2002, when the Faculty of Electronics from Niš, Serbia, joined the Faculty of Communication and Communication Technologies from Sofia, Bulgaria and the Faculty of Technical Sciences from Bitola, North Macedonia, in organizing the series of Conferences.

As to the previous ICEST Conferences, we had papers and authors from institutions all over the world. This year we had 230 authors (and coauthors) from 16 countries with 92 scientific and application oriented papers for oral and poster presentations.

In spite of the tight Conference schedule I hope that there was enough time for social activities which would enable further strengthening of the professional and personal relations among the ICEST participants for the benefit of the institutions and the countries they were coming from.

At last, in the name of the Conference Technical and Program Committee I want to express my gratitude to the authors and reviewers who have contributed to maintain the high standards for ICEST, and to all others who were involved in organization of the Conference.

I am sure that the beautiful and picturesque Ohrid will give you all, an inspiration for fruitful work and pleasant time during the ICEST Conference.

Prof. D-r Mitko Kostov,
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TABLE OF CONTENTS

SESSIONS PER TOPICS

RADIO COMMUNICATIONS, MICROWAVES, ANTENNAS & TELECOMMUNICATION SYSTEMS AND TECHNOLOGY

SIGNAL PROCESSING & DIGITAL IMAGE PROCESSING

COMPUTER SYSTEMS AND INTERNET TECHNOLOGIES & INFORMATICS AND COMPUTER SCIENCE

ELECTRONICS

ENERGY SYSTEMS AND EFFICIENCY

CONTROL SYSTEMS

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Application of Artificial Intelligence for Traffic Data Analysis, Simulations and Adaptation

Daniela Koltovska Nechoska[1], Renata Petrevska Nechkoska[2] and Renata Duma[3]

Abstract – **The application of Artificial Intelligence (AI) in traffic management and control is aimed at overcoming the challenges of increased travel demand, safety concerns, noise reduction, congestion, and environmental effects. This paper gives an overview of the current status, trends, and challenges in applying AI to address transportation problems and initial insights from a managerial perspective in terms of adaptation. The automated traffic data collected by the Good Vision AI-based cloud tool are used to perform an analysis of traffic flows.**

Keywords – **artificial intelligence, intelligent transport systems, Good Vision tool, traffic data analysis, simulations, adaptation.**

I. INTRODUCTION

Nowadays, there is no longer any doubt that Artificial Intelligence (AI) development can provide unprecedented opportunities to enhance the performance of different industries and businesses, as well as including the transport sector. Transportation problems become challenges when the systems and the user's behavior are too difficult to model and predict travel patterns. By sharing the characteristics of applicability in real-time and adaptation, the capability of self-analyzing by errors and success, learning and improvement (over time) interacting with the environment, and quick learning from a large amount of data, AI is deemed to be a good fit to overcome the challenges of increasing travel demand, traffic congestion, safety concerns, and environmental degradation [1]. These challenges arise from the steady traffic growth due to the increasing population in urban areas, especially in developing countries [2].

The AI applications in transport have been developed and implemented in a variety of ways from better utilization of accurate prediction and detection models aiming to better forecast traffic volume, traffic conditions, and incidents to the improvement of public transport and the use of a self-driven car. An important complementary principle in these approaches is also adaptation to dynamic circumstances and diverse contexts, which help proper management of the higher-level systems as well as on the operational level.

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Almost every organization in the transport industry, traffic engineers, and researchers have difficulty collecting accurate traffic data. Traffic data collecting and monitoring are difficult tasks in a congested urban network, especially at signalized intersections. Conventional monitoring methods are manual, expensive, and time-consuming, and they require the use of significate human resources. Additionally, they are subjective due to human factors and can produce inaccurate or incomplete monitoring results. The accuracy, completeness, consistency, and reliability of the traffic data is a 'condicio sine qua non' in the development and validation of simulation models. In this paper, we give a concise overview of the AI technologies that are currently used in transport, with a focus on their use in automated traffic data collection, analysis, and simulations. For the purpose of this study, we used an AI-based software – Good Vision, to collect detailed data about traffic flow, travel time, queue, waiting time in the queue, time gaps, etc. on two congested signalized intersections located in the city of Bitola, North Macedonia. Initial recommendations for adaptation are provided for the management of the transport systems.

II. AI AND INTELLIGENT TRANSPORT SYSTEMS SERVICES

Intelligent Transportation Systems (ITS) have used various AI approaches to deliver new services in recent years, mostly due to the progressive expansion in the worldwide population and the complexity of their mobility needs. These services usually involve managing a significant amount of traffic data generated by all users of the traffic system that can be procced without AI-based approaches.

Artificial Neural Networks (ANNs), Genetic Algorithms (GA), Fuzzy Logic (FL), Expert Systems (ESs), and Reinforcement Learning (RL) are some of the Artificial Intelligence-based techniques that are usually applied in ITS [1]. These feed into any managerial, governance self-organization system and provide proper change management and adaptation.

A brief theoretical description of the aforementioned techniques follows in the continuation.

- ANNs have some characteristics, such as adaptive learning, self-organization, and fault tolerance, and they are commonly used to solve problems to pattern recognition, optimization, and data mining.
- GA are heuristic search methods that use evolutionary biology and natural selection strategies to find solutions. They are frequently used to explore huge and complex

datasets, and they are adept at solving optimization issues in a variety of sectors, including robotics, telecommunications, medicine, and transport.

- FL mimics the human reasoning capacity to make rational decisions; FL is commonly used in solving a variety of complex problems including industrial processes, driving comfort, recognition of handwritten symbols, and prediction systems.
- ESs are based on rule-based and approached and predefined knowledge. They store knowledge about a specific field and can solve problems by using logical deduction based on that knowledge. Telecommunications, medicine, and transport are some of the fields that use ESs. [3].
- RL is a subfield of machine learning, learning what to do i.e., how to map the state into actions, how to maximize the numerical reward, and in which way [3]. RL and Deep RL are used in adaptive traffic signal control strategies, autonomous vehicles, robotics, web system configuration, etc.

ITS being a new type of Traffic Management System (TMS) has been gradually replaced by automated control systems [2]. Due to their ability to the prediction of various hazard situations, they become a powerful decision-making tool if a large volume of complex data set is used. In this context, ITS has also had an impact on the efficient operation of transportation networks through automated data collection.

The common characteristic of typical ITS is the need for specific input data from a variety of devices and sensors in real-time, embedded in the road infrastructure, vehicles, and traffic management and control infrastructure. These data are monitored and processed remotely and insights derived from the data are valuable input for the government, local policymakers, and businesses to make appropriate decisions. Through a feedback mechanism, this systems approach provides a continual performance improvement. Authorities monitor the data and ensure that timely data is disseminated to the commuters, drivers, and pedestrians thus benefiting the stakeholders [1].

By combining precise and real-world data from automation tools the process of designing a traffic simulation model can be faster and more accurate. This is most important when a new control strategy needs to be developed and tested. This paper focuses on the first stage - the implementation of a new, unconventional tool for traffic data collection based on an AI-based cloud. The applied methodology will be described in the next section.

III. Applied Methodology

The urban intersections are a vital element of transport infrastructure and have a significant impact on traffic efficiency and environmental aspects [4]. These ever-growing problems of the modern world require a keen observation and smart and sustainable solutions. With the development of new technologies, software such as PTV VISSIM can be used to test the proposed solutions before implementation, erasing any uncertainty about whether the recommended solution is the right one.

PTV VISSIM is a microscopic traffic simulator that is used for traffic modelling of urban road networks, highways, public transport, etc. It analyzes the movements of vehicles under various restrictions such as lane configuration, traffic signals, transit stops as well as offers the possibility of 3D simulation of realistic scenarios which makes this software an important tool for evaluating traffic performance and measuring the effectiveness of different alternatives of traffic engineering [5]. Stage 2 of this study, will be devoted to the identification and analysis of the traffic problems that occur during the peak hours at defined intersections, and to the investigation of the possibility of introducing an adaptive signal control.

The intersections in question are located in the wider central urban area of the city of Bitola, North Macedonia as displayed in Fig.1. The analyzed congested intersections are controlled by a fixed–time signal strategy.

The various traffic data needs to be collected for insight into traffic behavior. To achieve this goal the newest tool Good Vision has been implemented for the first time in our country [6]. To obtain traffic data from the field, the software needs to be fed by traffic videos.

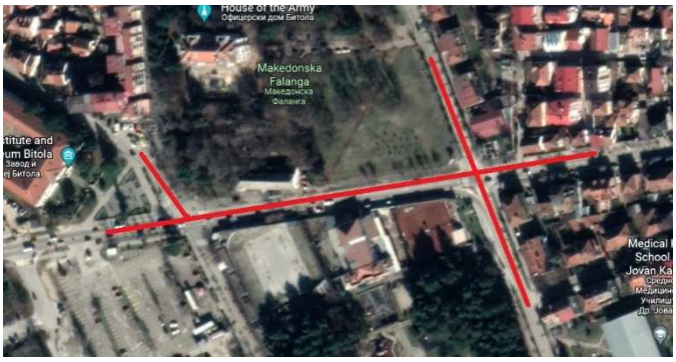

Fig.1. Area of research

Two video cameras were placed on these intersections to capture the traffic during the peak hours (14-16h) on December 22, 2021. The process of manual collection of traffic data even from a video can be excruciating and the collected data can often be unreliable and difficult to analyze. Therefore, the automatic collection of traffic data is gaining momentum as more software and applications are available for this purpose.

Recent advances particularly in data storage, data processing, and communications have enabled the storage and processing of big amounts of video data and the development of new applications that are not limited to feature sets. It is now possible to implement object detection and tracking, behavioral analysis of traffic patterns, number plate recognition, and automated security of video streams produced by traffic monitoring and surveillance cameras [7].

On that account, for this research study, an AI-based cloud software (Good Vision) was used to analyze the captured videos for the automatic collection of traffic data [6].

The Good Vision software uses proprietary AI technology to process videos from fixed cameras, drones, live streams, or other data sources. The software offers a classification of 8 types of vehicles: car, van, truck, heavy truck, bus, motorcycle, bicycle, and pedestrian (Fig. 2). Other parameters that can be obtained are: traffic counts, turning counts, origin-destination counts, exact vehicles trajectories visualization, occupancy times, delays, waiting time in the queue, travel time, speed, time gap, peak traffic hours, saturation flows, acceleration, and deceleration zones, queue lengths, stopped vehicles detection and even detecting traffic violations. This data can be obtained for the whole intersection at once or by approaches or directions.

Aside from the data, this software also offers automated traffic model calibration as well as the generation of a VISSIM compatible model with the specific parameters that are needed, allowing for creating an exact digital twin of the real scene in VISSIM.

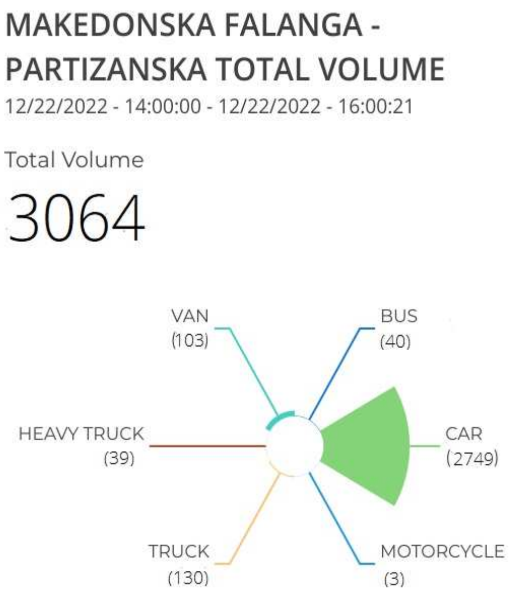

Fig. 2. Classification of vehicles count using Good Vision

Presented below (Table I and Fig.3) examples of the data that was acquired through this software are depicted. Detailed time gaps per vehicle, entry and exit time, and travel time have been obtained, additionally with the detection of exact vehicle trajectories.

TABLE I
VEHICLE LIST

CLASS	TIME GAP (s)	ENTRY TIME (East)	EXIT TIME (South)	TRAVEL TIME (s)
CAR	6.52	2022-12-22T14:11:37.660	2022-12-22T14:12:07.620	29.96
CAR	51.72	2022-12-22T14:12:29.380	2022-12-22T14:12:35.460	6.08
CAR	6.24	2022-12-22T14:12:35.620	2022-12-22T14:12:56.758	21.139
CAR	16.56	2022-12-22T14:12:52.180	2022-12-22T14:13:04.773	12.594
CAR	4.08	2022-12-22T14:12:56.260	2022-12-22T14:13:02.706	6.447
TRUCK	2.96	2022-12-22T14:12:59.220	2022-12-22T14:13:07.180	7.96
CAR	55.08	2022-12-22T14:13:54.300	2022-12-22T14:14:10.380	16.08
CAR	11.12	2022-12-22T14:14:05.420	2022-12-22T14:14:11.980	6.56
CAR	3.32	2022-12-22T14:14:08.740	2022-12-22T14:14:18.820	10.08
VAN	35.32	2022-12-22T14:14:44.060	2022-12-22T14:15:15.900	31.84
CAR	10.32	2022-12-22T14:14:54.380	2022-12-22T14:14:57.158	2.779
CAR	17.56	2022-12-22T14:15:11.940	2022-12-22T14:15:18.420	6.48
CAR	5.88	2022-12-22T14:15:17.820	2022-12-22T14:15:22.580	4.76
CAR	9.6	2022-12-22T14:15:27.420	2022-12-22T14:15:31.180	3.76
CAR	43.28	2022-12-22T14:16:10.700	2022-12-22T14:16:56.997	46.298
VAN	2.56	2022-12-22T14:16:13.260	2022-12-22T14:16:15.500	2.24
CAR	24.84	2022-12-22T14:16:38.100	2022-12-22T14:16:59.340	21.24
CAR	27.561	2022-12-22T14:17:05.661	2022-12-22T14:18:00.820	55.159
CAR	6.319	2022-12-22T14:17:11.980	2022-12-22T14:17:13.980	2
CAR	39.72	2022-12-22T14:17:51.700	2022-12-22T14:18:03.552	11.853

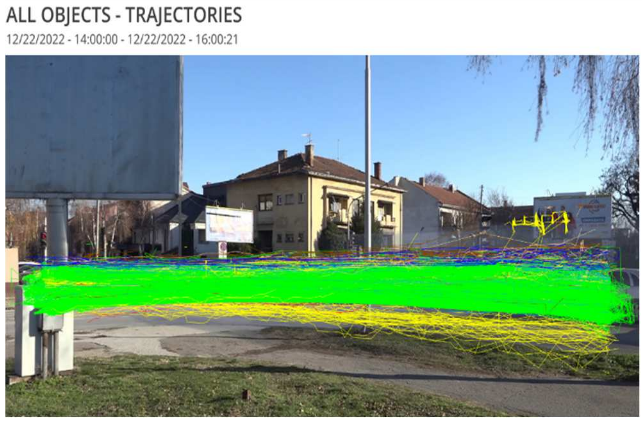

Fig.3. Exact vehicles trajectories

Some of the challenges that need to be addressed in the next stage are i) better positioning of the cameras or ideally; ii) using a drone, which would contribute to more uninterrupted data.

Future research will be directed towards a collection of more data for the morning peak hours as well as the afternoons and proposing a solution that will alleviate congestion, reduce travel time and minimize the waiting queues.

IV. THE CHALLENGES OF AI APPLICATION IN TRANSPORT

Some of the identified challenges while using AI applications can be summarised as follows [:

i) If AI techniques are based on data obtained from traditional methods such as loop detectors, they will not provide accurate on-time predictions. To address this, new AI-based technologies that can deliver novel and simply deployable data mining techniques are needed.

ii) The current AI techniques are unable to address whether conditions, as well as the development of weather and incident-sensitive algorithms and forecast schemes, are necessary to achieve high accuracy [2].

iii) Today, we are witnessing that AI applications are confronted with numerous ethical, social, financial, and legal questions mostly related to cybersecurity, data protection, and privacy. The challenge is a lack of clear policies, resistance to adopting new technologies, and lack of establishment or ethical regulations [2]. A survey conducted by Eurobarometer on autonomous systems found that respondents were very comfortable with autonomous vehicles transporting goods rather than traveling in such vehicles themselves [2]. On the note of complex systems, their self-organization as well as management and facilitation, we can conclude that AI application in transport, especially in the context of the simulated area can be useful for informing the authorities, as well as direct participants, on the given structures, expected and planned behavior, as well as assist them to perceive discrepancies and undertake corrective actions, especially in the urgent matters and infrastructural important zones. The recommended approach is as in the case of, for example, Intelligent Transport Management Systems (ITMS), "specially designed and architected to replace tedious manual processes to track, regulate, and analyze vehicle movement on roads and enforce traffic rules for the safety of citizens and their properties. It acts as a true decision support system for traffic planners and traffic law enforcement agencies" [9]. Step furthermore would be the example of an Integrated Traffic Management System (ITMS) [10] where adaptation is incorporated and there are both centralized and decentralized modules and points.

V. Conclusion

This paper presents an overview of the application of AI in traffic management and control. In particular, we focused our analysis on the current transport fields that benefit from AI-based technologies and especially on automated traffic data collection. A methodology for the implementation of an unconventional tool for traffic data collection through the processing of video data into an AI-based software for more accurate and detailed information is presented. This first stage of the research identified opportunities, limitations, and constraints of the use of services of the newest tool. The acquired data from the software is going to be used in creating a traffic simulation model for the evaluation and analysis of signal-controlled intersections in an urban area.

The managerial connotation present in this research exists to provide an anchor and big picture perspective of the approach, channeling the efforts in the proper direction.

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