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COMPUTER VISION BASED SYSTEMS IN SMART CITIES: CURRENT APPLICATIONS AND CHALLENGES

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In recent years, with a growing urbanization around the world the more urban issues have occurred that affect the quality of life in cities. To address these issues, cities are becoming smarter by using advanced technologies. Computer vision is one of the important technologies that was developed in the area of smart cities, that provides smart and practical solutions to a range of urban issues. Many applications of CV technology, including vehicle and pedestrian identification, monitoring, and mobility management, have helped to shape the ideas behind smart cities. In this paper, we will look at how computer vision solves urban problems and what challenges it has in implementation. This survey paper aims to present an overview of computer vision applications in the context of smart cities, providing studies on Computer Vision. The paper reviews the different papers on computer vision's applications and smart city. The computer vision has an important effect on urban planning, regarding issues of traffic control, urban mobility, public transport. However, there are some risks that could occur with the implementation of CV-based systems, such as violation of privacy, technical errors. The overall goal of this survey paper is to present the applications of computer vision in smart cities, that help in the detection of pedestrians, vehicles and road signs to improve traffic and mobility in urban settings. The article also provides some solution to issues that can occur with Computer Vision based systems in smart cities [1].

More recently, the development of computer vision has enabled urban planners to use systems based on these technologies to solve urban problems. Different aspects of Smart city concept can be developed using CV tasks in the near future. CV algorithms detect the vehicles and pedestrians after analyzing the data from city cameras, so the improvement in urban mobility and traffic management is expected. Also, the transportation system is one of the important aspects of Smart city, so image recognition tasks of CV improve this component of Smart city as well. On the other hand, the privacy of citizens is an issue with the implementation of the Computer Vision based systems in the cities [2].

There are a number of ways in which Computer Vision can be used to develop urban environments for pedestrians, cars and public transport alike. For example, convolutional neural network (CNN) can be used to train on

images to be able to recognize features of the image. Images of bus stops can be used as training data for CNN to be recognized later by the systems. The CNN also increases the detection performance of parking signs. Together with CNN the region proposal network (RPN) can be used to detect pedestrians more effectively.

Many experiments and scientific studies have been conducted to reveal the effectiveness of computer vision in solving urban problems and building a smart city. One of such researches studied the vehicle detection in traffic flow using lowframe cameras. The study achieved an 89% matching accuracy of vehicles from the images. Another studies have used computer vision techniques to detect the bus stop signs and parking signs. The system, with a trained CNN, installed on a device of the bus could recognize 97% of testing images of bus stops, and could work with differences in lighting and weather conditions [3]. The vehicles with a system to recognize parking signs had a high accuracy in various lighting and weather conditions, and the average precision was 98.56% of detecting and classifying parking signs. Different crucial studies were observing the pedestrian detection using Computer Vision applications. The pedestrian tracking systems that were 2 used during COVID-19 pandemic found that on average 70% of pedestrians on the streets followed the social distancing rules, and with behavioral interventions increasing this value up to 20% [4]. Different pedestrian tracking system named Fast R-CNN, which combines RPN and CNN, had better performance, compared to state-of-the-art method of tracking objects, in terms of average precision of detecting pedestrians. Also, the different research investigated that pedestrian tracking systems Histogram Oriented Gradient (HOG) and Support Vector Machine (SVM) have a better accuracy with high resolution images, which means that resolution is very important to these pedestrian tracking systems.

The results of these studies show the effectiveness and importance of Computer Vision technology in building Smart Cities. CV techniques are helpful in solving problems of traffic control, public safety and urban planning. By tracking vehicles and traffic flow the urban planners can make decisions to design city more effectively with less accidents and traffic congestion, so the traffic information received from CV-based systems are used for decision-making [5]. One of the main points of smart city is the safety and comfort of pedestrians are improved by CV-based systems, as they can detect their location in a case of threatens from vehicles, which leads to change in policies in the road. Also, the installation of cost-effective wireless cameras could help to make cities smarter, with strong public safety as they have systems that use CV technology to process specific data [7]. However, implementation of systems with Computer Vision technology can have different issues. For instance, there could be technical problems with installing systems, and during their work, or the government policies could affect the smart city concepts [6]. Also, urban planners should keep in mind that Computer Vision techniques do not provide with 100% accurate and correct data, so there are risks of errors in the outcomes.

With the developing Smart cities using Computer Vision technologies there are some

ethical issues. It is the issue of privacy of citizens. The cameras that track people can be hacked and the personal data of the people can be lost. The study on data security in smart cities suggest some ways to protect data, such as encryption, access control and the engagement of government [8].

In conclusion, the Computer Vision technology plays significant role in the concept of Smart City by helping to track and detect vehicles, pedestrians and road signs. CV helps to improve the traffic management, public safety and public transport aspects of the city hence making the lives of urban residents more comfortable. However, computer vision engineers, city authorities and urban planners should understand that there are technical risks of the CV-based systems, and also the ethical issues should be considered.

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References

1.Chew, R. F., Amer, S., Jones, K., Unangst, J., Cajka, J., Allpress, J., Bruhn, M. (2018). Residential scene classification for gridded population sampling in developing countries using deep convolutional neural networks on satellite imagery. *International Journal of Health Geographics,* 17(1).

2.Guo, Y., Liu, Y., Oerlemans, A., Lao, S., Wu, S., Lew, M. S. (2016). Deep learning for visual understanding: A review. *Neurocomputing,* 187, 27–48.

3.Bottino, A., Garbo, A., Loiacono, C., Quer, S. (2016). Street Viewer: An Autonomous Vision Based Traffic Tracking System. *Sensors*, 16(6), 813.

4.Derek Gloudemans, Nicole Gloudemans, Mark Abkowitz, William Barbour, and Daniel B. Work. (2021). Quantifying social distancing compliance and the effects of behavioral interventions using computer vision. In Proceedings of the Workshop on Data-Driven and Intelligent CyberPhysical Systems, DI-CPS'21. Association for Computing Machinery.

5.Gautham Krishna Gudur, Ateendra Ramesh, and Srinivasan R. (2019). A vision-based deep on- device intelligent bus stop recognition system. In Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers.

6.Amirkolaee, HA, Arefi, H. (2019). Height estimation from single aerial images using a deep convolutional encoder-decoder network. ISPRS Journal of Photogrammetry and Remote Sensing, 149, 50–66.

7.Ibrahim, M. R., Haworth, J., Cheng, T. (2019). URBAN-i: From urban scenes to mapping slums, transport modes, and pedestrians in cities using

deep learning and computer vision. Environment and Planning B: Urban Analytics and City Science, 602–610.
8.Dingjie Zhang, Xiaochun Lei, Zhiying Liang, Yunhao Li, and Huiying Qin. (2021). Application of computer vision in intelligent transportation management system. In 2021 10th International Conference on Internet Computing for Science and Engineering, ICICSE 2021, 105–109.