International Journal of Research in Engineering, Science and Management
Volume 5, Issue 7, July 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Detecting Driver Assaulting and Attacks Event for Hazardous Material Transportation

Shihong Li[1], Xiangbo Wang[2], Lifeng Zhao[3], Zhipeng Chen[4], Yaping Fan[5], Lu Yang[6], Helix Xie[7], Ning Zhou[8], Sumei Xia[9], Qihui Wang[10], Yan Wang[11], Wenhui Shen[12], Xiaoxin Pi[13], T. R. Chen[14], Shuashua Mao[15*]

[1,2,3,4,5,6]*Digitalization and Information Center, Changqing Oilfield, PetroChina, Xi'an, China*

[7,8,9,10,11,12]*Zhejiang Sunleads Beidou Navigation Tech. Co., LTD., Huzhou, China*

[13,14,15]*Mafu Laboratory, Moxin Tech., Huzhou, China*

***Abstract*: Ensuring the safety of hazardous material transportation is essential. Many previous works have made efforts in designing preventive measures to avoid disastrous accidents, such as through careful route planning and strict regulatory requirements. However, there are also external hazards of human aspects for hazardous material transportation – for example, the terrorism. Since 9/11, terrorism has become an ongoing hot-button issue worldwide. Due to the very nature of hazardous materials transport vehicles, once these vehicles are targeted by terrorism, they become a tool for destroying cities, governments, and societies. Some past works have discussed the assessment and the avoidance of terrorist attacks for hazardous material transportation theoretically, we hereby present our solution that directly monitors and detects driver assaulting & attacks event using on-board cameras and computer vision techniques. In this work, we summarized the related techniques that can be applied to the detection and assessment of assaulting & attacks event, and provide insights into how the detection and assessment can promote the safety of transportation and a larger group of population.**

***Keywords*: computer vision, hazardous material transportation, tourism.**

1. Introduction

The transport of hazardous materials (Hazmats) plays an essential role in the functioning of cities and society [1]. Hazardous materials, which are toxic, corrosive, explosive, flammable, and combustible, are often highly susceptible to significant hazards in a traffic accident involving transport vehicles. Therefore, generally, only those who have been strictly audited by the relevant state authorities and have the appropriate facilities and equipment to ensure the safe transportation of hazardous materials are qualified to carry out the transportation of hazardous material [2]. A range of measures needs to be applied to ensure the safety of hazardous material transport, which has been explored in many past studies [3]–[6].

For regulatory authorities, vehicles have to be registered with the relevant authorities, the vehicles transporting hazmats have to have their exhausts treated accordingly, they have to be fitted with spark-proof devices, vehicles have to be equipped with GPS systems, and complete monitoring of the transport process, equipped with reliable safety facilities such as crash beams and anti-static, and vehicles have to be equipped with anti-toxic and anti-corrosion type masks as well as medical first aid. The driver should have a hazardous materials transport qualification, material driving habits, and take adequate measures to deal with unexpected situations. The requirements for transport companies are a license to engage in the transport of hazardous materials by road, special vehicles for the transport of hazardous material, drivers with qualifications, loading and unloading managers, escorts, etc., and the necessary communication tools for the transport of hazardous materials, and a sound management system for safety operation [4], [7]. All these measures can guarantee the safety of the transportation of hazardous material to a certain extent.

However, in addition to the safety measures mentioned above, one factor that has always existed and is gaining more and more attention - terrorist attacks - is also a potential factor affecting the safety of hazardous materials transportation. Since 9/11, terrorism has become an ongoing hot-button issue worldwide [8]. Due to the very nature of hazardous materials transport vehicles, once these vehicles are targeted by terrorism, they become a tool for destroying cities, governments, and societies [9].. It is essential to examine the safety of hazardous material transportation regarding terrorism.

Therefore, this paper focuses on how to avoid external hazards while transporting hazardous materials, such as terrorist activities from outside the vehicle or harassment of the driver inside the vehicle. We need to obtain a monitoring method to detect and alert the situation in a timely manner, which has been little addressed in previous studies. In the remainder of this paper, we review the research related to hazardous materials transportation security, and terrorist attacks, then present our desire to use computer vision methods to detect and warn of dangerous behavior, we summaries related work. Finally, we present future directions and perspectives based on a literature review.

*Corresponding author: moxin@wingmail.cn

2. Hazardous Material Transportation and Terrorist Attacks

Past work and numerous cases have pointed out that hazardous materials make hazardous chemical transport vehicles an easy and attractive target for terrorism [9]. Terrorists have also used hazardous materials to attack critical public facilities because they are transported in cities and highways that are flammable, explosive, corrosive, toxic, or pose extreme danger to the population [10]. For example, the sarin gas incident in the Tokyo underground killed 13 people and injured approximately 6,300 [11]. Once these vehicles are targeted by terrorism, they will become a tool for destroying cities, governments, and societies, and the damage caused will be enormous. Therefore, there is an urgent need for viable solutions to avoid and anticipate such situations in advance.

In the work [12], an innovative safety and security game model has been developed for the transport of hazardous materials on urban road networks (HTSG). This is a theoretical model - in the classical hazardous materials transport problem, game theory is used to find the optimal route. In the newly proposed approach, game theory is also used to obtain and analyze defense strategies against possible attacks, considering different risk scenarios urban road networks face. Secondly, the authors propose a new comprehensive risk index system to assess the risk level of each road that makes up the urban transport network and develop a labeling method called 'most critical' to classify the critical edges in four risk scenarios and then propose a mathematical model to analyze the consequences of the risk according to the different risk scenarios. The authors have validated the proposed model and methodology based on the existing road network in Beijing. It demonstrates how the proposal can help the government develop defensive attack strategies and allocate defense resources for safer transport of hazardous materials in the city. Furthermore, the solution method based on a zero-sum game theory model will help defenders (e.g., government entities responsible for urban safety) to identify vulnerable roads (streets, highways, etc.) and the types of risks they face, build risk-reducing defense strategies, and allocate resources for the defense of these vulnerable points under different risk scenarios.

The work [13] proposed use of dynamic geographic events allows the immediate location of terrorist attacks on a geographically aligned map with the possibility of dynamically evolving scenarios and the number of people involved. Dynamic techniques are created using the resulting simulation code and the output of GIS software.

3. Detecting Terrorist Attacks Using Computer Vision Techniques

Previous work summarized above is based on theoretical analysis, which relies on a large number of assumptions. However, a system that can be used in real life is far from being able to apply the theoretical framework described above to solve the problem. Here, we show for the first time that a computer vision approach can be used to detect terrorist attacks on hazardous chemical vehicles.

Recent advances in machine vision technologies have enabled many possibilities in realm of transportation safety, techniques including lane-detection/segmentation [14], [15] and semantic segmentation [16]–[18] have been widely introduced and developed, as well as the recognition and classification tasks [19]–[22], and is used for monitoring and even autonomous driving. In this paper, we exploit machine vision techniques in behavior analysis, by monitoring the behavior for people that are in or near the vehicle.

In the past, some work has demonstrated in-house detection of harassment or assault by drivers, including bus drivers and taxi drivers, and detecting this type of behavior can prevent this from happening. For example, [23] has designed an algorithm that identifies the captured image, extracts the region of interest from the screen area, and then matches it in an existing database. If a match exists, it proceeds to the tracking and monitoring phase. Next, the identified areas of interest are tracked to detect aggressive movements (based on movement trajectories, etc.). The system proposed in [24] is also divided into two parts: recognition as well as tracking. The face recognition algorithm extracts the face part of the image, then tracks the object in motion in the image based on a series of images in the video, and then determines the current action performed by the object and the events occurring in the vehicle based on the tracked movements.

Some work elaborates on anomalous behavior obtained from external ingestion, mainly deviant behavior containing aggression, and [25] provides an algorithm for detecting dangerous/deviant behavior near ATMs that can be extended to driving systems. The training video is first used to form a model database through a number of pre-processing (RSS) and feature extraction (using HOG) operations, after which the same process is used to extract features from the test image, and then the extracted features are matched in the model database and classified (the three methods mentioned on the left) to complete the action/event recognition. And [26] provides a behavior detection pipeline, which starts with a detection part, using a pre-trained YOLO model for pedestrian detection. If a pedestrian is detected (the IOU setting guarantees only one detection), the next step is performed. The next step is to eliminate the perspective effect caused by the camera through a geometric transformation and then obtain the target's center position. The movement of the center position is used to determine the type of trajectory and the speed of motion, and thus the current behavior of the target, compared to the pre-defined dangerous behavior. This allows us to identify whether the attack is hazardous or not.

4. Conclusions and Discussions

This paper suggests that harassment or assault against drivers is one of the potential risk factors affecting the safety of hazardous materials transport, considering the specificity of hazardous materials transport itself. The paper suggests that, in addition to using a theoretical framework to assess risk levels, it is possible to make direct use of the already installed in-vehicle and external cameras, equipped with the function of

detecting abnormal risk behavior, to help improve the safety of hazardous materials transport and avoid safety incidents due to terrorist attacks or harassment of drivers. Machine vision and machine learning tools are instrumental in such scenarios. It is worth pointing out that action recognition and behavior recognition has been a long-standing topic in the field of computer vision [27]. In the future, the development of algorithms for this category will require the development of lighter and more instantaneous algorithms with better robustness and generalizability to be able to use the algorithms in a wider range of scenarios.

It is worth noting that detection of the external environment can also serve to build safety in cities. For example, [28] proposes that areas of potential danger can be monitored on a large scale utilizing edge computing, with final detection carried out by a central system with high computing power. Every hazardous vehicle running on the road itself already comes with its own camera in accordance with regulatory requirements, and using these edge terminals for computing, it is also possible to be informed of the safety situation in different areas of the city on a dynamic basis, which would benefit a wider group of people.

References

[1] E. Erkut, S. A. Tjandra, and V. Verter, "Hazardous materials transportation," *Handbooks Oper. Res. Manag. Sci.*, vol. 14, pp. 539–621, 2007.

[2] E. Erkut and V. Verter, "Modeling of transport risk for hazardous materials," in *Oper. Res.*, vol. 46, no. 5, pp. 625–642, 1998.

[3] X. Liu, M. R. Saat, and C. P. L. Barkan, "Integrated risk reduction framework to improve railway hazardous materials transportation safety," in *J. Hazard. Mater.*, vol. 260, pp. 131–140, 2013.

[4] Q. Yang, K.-S. Chin, and Y.-L. Li, "A quality function deployment-based framework for the risk management of hazardous material transportation process," in *J. Loss Prev. Process Ind.*, vol. 52, pp. 81–92, 2018.

[5] M.-H. Leroux, N. de Marcellis-Warin, and M. Trépanier, "Safety management in hazardous materials logistics," in *Transp. Lett.*, vol. 2, no. 1, pp. 13–25, 2010.

[6] X. Yang, C. Ma, C. Zhu, B. Qi, F. Pan, and C. Zhu, "Design of hazardous materials transportation safety management system under the vehicle-infrastructure connected environment," in *J. Intell. Connect. Veh.*, 2019.

[7] P. K. Raj and E. W. Pritchard, "Hazardous materials transportation on US railroads: application of risk analysis methods to decision making in development of regulations," in *Transp. Res. Rec.*, vol. 1707, no. 1, pp. 22–26, 2000.

[8] B. L. Nacos, Y. Bloch-Elkon, and R. Y. Shapiro, "Post-9/11 terrorism threats, news coverage, and public perceptions in the United States," in *Int. J. Confl. Violence*, vol. 1, no. 2, pp. 105–126, 2007.

[9] L. Zhang, G. Reniers, B. Chen, and X. Qiu, "CCP game: A game theoretical model for improving the scheduling of chemical cluster patrolling," in *Reliab. Eng. \& Syst. Saf.*, vol. 191, p. 106186, 2019.

[10] C. Santos, T. El Zahran, J. Weiland, M. Anwar, and J. Schier, "Characterizing chemical terrorism incidents collected by the global terrorism database, 1970-2015," in *Prehosp. Disaster Med.*, vol. 34, no. 4, pp. 385–392, 2019.

[11] Y. Tokuda, M. Kikuchi, O. Takahashi, and G. H. Stein, "Prehospital management of sarin nerve gas terrorism in urban settings: 10 years of progress after the Tokyo subway sarin attack," in *Resuscitation*, vol. 68, no. 2, pp. 193–202, 2006.

[12] Y. Li, J. Wu, W. Yuan, and E. D. R. S. Gonzalez, "Securing transportation of hazardous materials against terrorism: A novel game-based approach," in *Comput. & Ind. Eng.*, vol. 169, p. 108156, 2022.

[13] M. F. Milazzo, G. Ancione, R. Lisi, C. Vianello, and G. Maschio, "Risk management of terrorist attacks in the transport of hazardous materials using dynamic geoevents," in *J. loss Prev. Process Ind.*, vol. 22, no. 5, pp. 625–633, 2009.

[14] Z. Liu and L. Zhu, "Label-guided Attention Distillation for lane segmentation," in *Neurocomputing*, vol. 438, pp. 312–322, 2021.

[15] D. Neven, B. De Brabandere, S. Georgoulis, M. Proesmans, and L. Van Gool, "Towards end-to-end lane detection: an instance segmentation approach," in *2018 IEEE intelligent vehicles symposium (IV)*, 2018, pp. 286–291.

[16] L. Zhu, D. Ji, S. Zhu, W. Gan, W. Wu, and J. Yan, "Learning Statistical Texture for Semantic Segmentation," 2021.

[17] X. Fu *et al.*, "Panoptic NeRF: 3D-to-2D Label Transfer for Panoptic Urban Scene Segmentation," *arXiv Prepr. arXiv2203.15224*, 2022.

[18] G. L. Oliveira, W. Burgard, and T. Brox, "Efficient deep models for monocular road segmentation," in *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2016, pp. 4885–4891.

[19] J. Azar, A. Makhoul, M. Barhamgi, and R. Couturier, "An energy efficient IoT data compression approach for edge machine learning," in *Futur. Gener. Comput. Syst.*, vol. 96, pp. 168–175, 2019.

[20] Y. Aviv and A. Pazgal, "A partially observed markov decision process for dynamic pricing," *Manage. Sci.*, vol. 51, no. 9, pp. 1400–1416, 2005.

[21] L. A. Austin, S. Osseiran, and C. L. Evans, "Raman technologies in cancer diagnostics," in *Analyst*, vol. 141, no. 2, pp. 476–503, 2016.

[22] L. Allen, M. W. Beijersbergen, R. J. C. Spreeuw, and J. P. Woerdman, "Orbital angular momentum of light and the transformation of Laguerre-Gaussian laser modes," in *Phys. Rev. A*, vol. 45, no. 11, p. 8185, 1992.

[23] J.-G. Yoo, D.-K. Kim, S. J. Choi, H. Lee, and J.-B. Kim, "A driver assaulting event detection using intel real-sense camera," in *Int. J. Control Autom.*, vol. 10, no. 2, pp. 285–294, 2017.

[24] J.-G. Yoo, S. J. Hun, C. S. Wook, J. Choi, and J.-B. Kim, "The Design of Detecting Public Transportation Driver Assaulting Event Using Object Tracking," in *Int. Inf. Inst. (Tokyo). Inf.*, vol. 19, no. 7A, p. 2719, 2016.

[25] V. Ashokan and O. V. R. Murthy, "Comparative evaluation of classifiers for abnormal event detection in ATMs," in *2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, 2017, pp. 1330–1333.

[26] G. Oltean, L. Ivanciu, and H. Balea, "Pedestrian detection and behaviour characterization for video surveillance systems," in *2019 IEEE 25th International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 2019, pp. 256–259.

[27] J. S. Hartford, J. R. Wright, and K. Leyton-Brown, "Deep learning for predicting human strategic behavior," in *Adv. Neural Inf. Process. Syst.*, vol. 29, 2016.

[28] B. Luo, S. Tan, Z. Yu, and W. Shi, "Edgebox: Live edge video analytics for near real-time event detection," in *2018 IEEE/ACM Symposium on Edge Computing (SEC)*, 2018, pp. 347–348.