International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 8 ǁ August 2022 ǁ PP. 204-207

Weather Conditions and Driving Safety of Hazardous Materials Transport

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Abstract
It is essential to ensure the safety of hazardous materials transport. Many existing works have proposed various ways to keep transportation safe, while in this work, we identified and explored overlooked aspects that affect the safety -- the local weather conditions. Adverse weather conditions like rain, snow, and frogs may significantly affect safe driving. Therefore, we argue that it is necessary to monitor the weather conditions in real-time, and computer vision algorithms can do it. The advances in computer vision techniques shed light on the realm of weather recognition, and we reviewed and compared existing algorithms in this work. We also listed the existing weather classification datasets and provided insights into how the combination of weather monitoring and hazardous materials transport facilitates road traffic safety.

Keywords:*Algorithm design, Hazardous material transportation, Safety sciences. Weather*

Date of Submission: 26-07-2022 Date of acceptance: 09-08-2022

I. INTRODUCTION

With the rapid development of the economy, the demand for hazardous material is increasing and the volume of hazardous material transported continues to expand in line with the growth in demand. Transporting hazardous material such as chemicals and petrochemicals requires careful, precise and robust processes. Because hazardous materialare inherently dangerous, an accident can have very serious consequences. Therefore, nothing can or can afford to happen to the safety of the transport of hazardous material, and it is essential that the strictest discipline is exercised and supervision and discipline is strengthened to ensure that nothing goes wrong.[1], [2] It is vital to ensure the safety of the transport of hazardous material.

Past work has already mentioned many measures to improve safety in the process of transporting hazardous material, such as strengthening staff training and vehicle management, using GIS methods for careful route planning, and even installing intelligent systems for monitoring and controlling the safe transport of hazardous material, so as to achieve timely and effective monitoring of the safe transport of hazardous material[3]–[5]. The specific situation of the transport vehicles, drivers and cargoes can be transmitted to the supervisory centre in the form of videos and pictures, thus playing an active and effective role in protecting the lives of transport staff and the safe transport of hazardous material.

However, there is one factor that affects the safety of the transport of hazardous material that is in fact not well integrated into current intelligent systems of safety control - that is, the environment. It is essential that the transport of hazardous material is investigated in advance, as adverse weather and transport conditions can increase the risk of hazardous material and make it more likely that serious accidents will occur. Environmental risks are related to weather conditions, road conditions and the surrounding environment. Weather conditions such as heavy rain, fog, snow, etc. can make the transport of hazardous material difficult.If snow or fog falls during the transport of hazardous material, it is easy for the roads to become slippery and visibility to be poor, and it can damage the braking performance of the vehicle and cause it to slip out of control, which can lead to dangerous accidents.

As a result, some work has been noted on the possibility of using GIS systems to make scheduling arrangements for the transport of hazardous material based on weather conditions[6]–[8], however, weather is a local and real-time phenomenon and accurate weather forecasting has so far been a challenge for academia and industry. Many times, severe weather tends to occur suddenly[9], [10], which may not be recorded by GIS systems, or hazardous materials transport vehicles may travel into areas that are not covered by the weather forecast itself - these limitations point to the need for a method that can detect the surrounding environment in

real time and facilitate the assessment of environmental factors during the transport of hazardous materials assessment to facilitate safe transport and information feedback.

The aim of this paper is to show that it is possible to use on-board cameras to not only identify road conditions, but also to observe real-time weather conditions, alerting drivers and control centres in time for warnings in case of bad weather, or even predicting local weather conditions, which would greatly benefit the safety of hazardous materials transportation.

II. EVALUATING WEATHER USING VISUAL CUES

Currently, traditional weather recognition relies on sensors or human vision. The installation and maintenance of the sensors requires a lot of human, material and financial resources, and the accuracy and real-time recognition of weather conditions can be affected by the surrounding environment, resulting in errors in weather recognition. In contrast, weather images are relatively easy to obtain. Lu et al.[11] used support vector machines to classify sunny and cloudy weather by extracting sky, shadow, mapping and fog features, while Roser et al.[12] and Yan et al.[13] used support vector machines to recognise sunny and rainy weather in an in-vehicle vision system by calculating the brightness, saturation and colour of different areas of weather images. Although these efforts have provided a number of solutions to the weather classification task, the results achieved by these methods have not been satisfactory. In contrast to typical image classification tasks, weather images are affected by a variety of factors such as illumination, reflections, scenes and shadows, which are highly coupled, making the weather classification boundaries of the images highly non-linear, and previous engineering methods have been unable to capture such classification boundaries.

In recent years, convolutional neural networks have made great strides in computer vision and have demonstrated powerful advantages in a wide range of image classification and tracking tasks. Applications have been made in many areas of transportation, including recognition and tracking [14]–[18], road information understanding[19]–[21], and even the transport of hazardous materials[22], [23].

Facing the difficulty of measuring a single statistical feature, specifically, with clear (cloudy) weather/rainy/snowy weather involved, combined with fog, etc. Zhao et al. [24] uses a CNN+RNN model for multi-label weather classification (item (iii) and item (iv)), and uses LSTM to perform step-by-step classification prediction of the features extracted by the CNN. Lin et al. [25] proposed a region selection and concurrency model for deep learning model, which is obtained by semantic segmentation of images followed by different semantic regions, and then replacing the original classifier with a network model to exploit the The original classifier is then replaced with a network model to obtain regional weather indications using the feature representations of the different regions, and finally synthesise The original classifier is then replaced by a network model, which uses the feature representation of different regions to obtain regional weather indications and finally synthesises the full-image weather judgement. The network model is then replaced by the original classifier to obtain regional weather indications using different region feature representations.

The existing methods lack of fully exploitation of the multi-scale of weather cues, which may reduce the ability to handle different scales of weather cues in weather cue segmentation. To address these issues, Xie et al. [26] propose a novel end-to-end convolutional neural network (CNN)-based multi-task weather recognition network with multi-scale weather cues (CMWRN). Specifically, weather cues are segmented by capturing multi-scale weather cue features, such as blue skies and dark clouds. By resampling weather cue features at multiple scales, arbitrary scale weather cue regions in outdoor images can be accurately and efficiently classified. In the weather classification task, a generalised pooling approach is introduced to generate a more discriminative weather representation. To further facilitate weather classification, multi-scale weather cue features are used to provide weather cues for the weather representation. Further, based on the problem of too little partial weather data, [27] proposes to first enrich the data structure using a GAN and then train it through a CNN, with both networks being optimised simultaneously.

These above methods give a good basis for capturing weather information using visual information for analysis. They can be directly applied to existing hazardous materials vehicles to evaluate local weather cues to promote safe driving.

III. MACHINE VISION DATASETS FOR WEATHER CLASSIFICATION

While the learning-based algorithms mentioned above are able to capture feature information of images more effectively than traditional methods to facilitate more accurate weather recognition, they all rely on high-quality training data. Currently, publicly available relevant weather datasets are still relatively small.

Liu et al. [11]offers a dataset that composed of 10,000 images of sunny and cloudy days. In[25], a multi-category benchmark dataset was constructed containing 65,000 images from 6 common categories of sunny, cloudy, rainy, snowy, hazy and thundery weather. This dataset also facilitates weather classification and attribute recognition. In [28], a multi-class weather image dataset called MWI was constructed. It contains 20,000 images obtained from many web albums and movies such as Flicker, Picasa, MojiWeather, Poco,

Fengniao, most of the images have completely different backgrounds. The images were collected by five volunteers who used their common sense to select the images. They were then asked to label all the images according to their common sense. The majority voting mechanism was applied to predict the final labels, i.e. to select the category that received the highest number of votes.

IV. CONCLUSION

The safe transport of hazardous material is of paramount importance and much past work has given a number of ways to improve the safety of hazardous chemical transport. In this paper we point out the need to consider the environmental factors involved in the transport of hazardous material, in particular the weather. We further point out that although weather forecasts can be used to assess the weather along the way, timely warnings and interventions are needed as hazardous materials vehicles in transit may enter areas that are not accurately covered by weather forecasts or encounter some localised severe weather phenomena that cannot be accurately captured by weather forecasts. This paper points out that the original on-board camera can be used to implement weather recognition based on machine vision technology to analyse road conditions while also observing weather characteristics and providing timely warnings of extreme weather. This paper reviews relevant research using machine learning methods for visual weather classification, as well as some of the datasets that are currently available. The paper points out that these methods provide a useful tool for weather monitoring in hazardous chemical vehicles. In the future, more datasets will need to be captured to allow for better generalisation of the network. More lightweight real-time algorithms also need to be developed to enable real-time weather monitoring at edge devices.

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