Fiber Bragg Grating Sensors based Vehicle Classification System Using SVM

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Abstract: Due to the heavy use of vehicles in transport, classification of vehicles is critical. The speed and tires of the vehicles can then be estimated at different times when the vehicles arrives at the sensor location and the speed is monitored by changes the rest of the travel sensor. The vehicle classification system in this article uses machine learning vector (SVM) algorithms to categorize vehicles into class from small vehicles to compact trucks. Traffic analysis consequences demonstrate that development systems can better evaluate vehicles classification. The vehicles are classified depending on the number of axes and the space (wheels) between them. The accuracy of the vehicles classification depends on the accuracy of the speed and steering wheel. In this study, a three-nine-gauge glass plate with Bragg grating sensor (3D GFRP-FBG) was presented to evaluate the speed of the vehicles and wheels. The ability of sensors to estimate the speed of vehicles and tires in more sophisticated search engines..

Key Words: SVM,FBG, Sensor, 3D GFRP,Fiber.

I INTRODUCTION

Gradually, the addition of lanes is becoming increasingly with the increase in vehicles, this is no longer a suitable solution to the problem of traffic congestion. One practical solution is to make better use of existing infrastructure and more efficient management. efficient traffic management necessitate the use of surveillance technology to determine the size of traffic that determines the characteristics and behavior of vehicles on the road ((i.e. vehicle velocity, traffic flow, travel instance, vehicle density, vehicle measurement, length of traffic jam, etc.).It is important to understand the vehicles count and the number of vehicles in each group this is especially significant for different traffic management purpose such as planning, traffic overcrowding avoidance and accidents prevention. The classification system for road vehicles requires two major components, including a two-lane road network, and a system for analyzing the data collected for the road. The classification. Riders can use a variety of technologies, as well as infrared sensors, passive microwaves or radar acoustic sensors, and motion recognition [8][9]. These influencers are simple to establish and maintain, but their effects will have a profound impact on atmospheric, environmental and climate elements [10][11], and harsh environments will be judged. 'the harsh world as well. Conditions situation such as wind, storm, winter and strapping winds.

In order to avoid the limits of road sensors, there is a wide range of technologies and road waves. [12] 13], piezoelectric wire and tube live fluid are despicable, but are statement to have high failure rates connected with the installation and use of substandard installation methods. the steep path. Above, the control limits are small, and the magnetic field has a significant impact on the environment. Piezoelectric sensors and sensors have a major obstacle, but are reported to be obstructing due to road conditions and vehicle speeds, and axles can be misplaced if trucks and buses are large.. In general, most electromagnetic sensors show significant dependence on the environment and there are restrictions on the classification of vehicles used in nature in the medium and long term, which does not extend the life of pavements.

Fiber-based technology has a few advantages that are attractive to the industrial planning industry. They are usually soft and unstable with electromagnetic inputs, withstand a harsh environment and able to cope with distributed emotions. As a result of telecommunications, fiber optic sensors have emerged for large networks and broadband system. though Fiber Bragg Gratings (FBG) was originally industrial for the telecommunications industry in the late 1990s, they are now widely used in applications and applications and be used. FBG is an optical strain machine that reflects a precise light and is embedded in the fiber of the fiber college. The wavelength of reflected light depends on the change in refractive time of the refractive plate or the modification distance of, which is located at the base of the fiber. The active composite is used as a band stop filter, allowing light at all wavelengths to be unobstructed by passing, and the reflectivity of a reflexive reflectivity is reflected by a thaw index of the core.. When applied to the Bragg fiber standard the Bragg measure shows the G radiation, which is the best index of price reductions = B = 2 • neff • the grating's maximum brightness is G of permanent light during the repeated sampling cycle and the Fiber scatter and rotate.

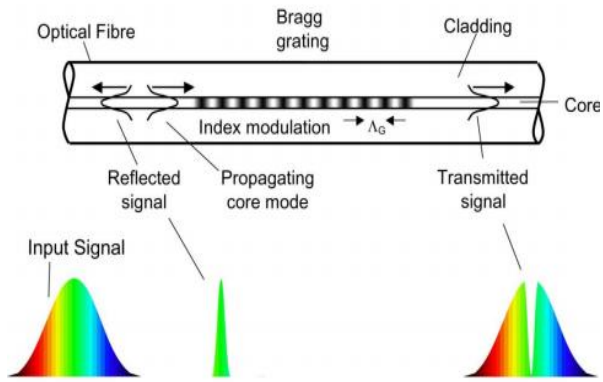

Fig. 1. Illustration of an FBG having an index modulation of spacing a single-mode optical fiber.

In adding together to telecom transmission, FBG is also suitable for therapeutic purposes, particularly temperature control and pressure. Optical components and light sources designed for the telecommunications industry can be used in sensor network function. As a complete optical device, the FBG box is protected by electromagnetic interfering (EMI), which frequently damages electronic sensors. Simple, easy to set up, light in weight, small in size and fast in response. Due to its high quality it is also ideal for sensors that hear the temperature and tension in a potentially explosive environment. It can make FBG vulnerable to force, curving, displacement, weight and refractive index. The purpose of the FBG acquisition is from the regeneration of the fiber and the sensitivity of the reaction time to the fiber for mechanical or external mechanical interference. Since the reflected light from the Bragg gradient depends on the detachment among the G index and the refignive neff index, the control field has a direct effect on the FBG response, that is, the G and causes the glass to break through light (i.e., the extension and pressure caused by the "strain"). Changes in the index.

The schematic diagram of the FBG is shown in Figure 1. Typically, the refractive signal processing in the core is produced by enabling hologram light inside content of optical marketing channels. Similar to film photography, researchers at the Canadian Telecommunications Research Center have found that the essence of traditional telecommunications services is motion picture [14]. They found that germanium, a common ingredient used for increasing the ethical redistribution of silicon dioxide in the fiber optic region, continues to increase the brightness of the design pressure when exposed to light high-visible or ultraviolet (UV) light. By moving high-speed lights through their lengths, changes can be made in the refignive industry to the core. In general, this exercise around the beam is accomplished by emitting ultraviolet light through a unique optical transmission with a warning signal, which can be controlled to eliminate light. -Server sending [2]. This diffusion grating is often referred to as the first line. Used as a mask. Most of the light emitted from the mask is mixed with the final interruption of these transitions, resulting in a modest change in the beam, which is transmitted along the length of the fiber.

II RELATED WORK

In modern years, optical fiber sensors have been used in appropriate to its little dimension, illumination weight, high sensitivity and high anti-electromagnetic interfering ability, traffic engineers apply it. They can also be used in harsh surroundings, such as high temperatures, coral and high temperatures. Humility [10]. This compensation can make available a viable sensor solution for long-term vehicle categorization. Among the variety of fiber sensors, Bragg Grating (FBG) is single of the majority frequently used sensors. FBG was first manufactured in optical fiber in Canada in 1978 [15]. FBGs have all the compensation of fiber optic sensors and have exceptional properties, namely high-quality solution and reuse [16][17], which can be used in large scale applications. However, because FBG gates are made of fiberglass, they are easily damaged when setting up internal sidewalks for vehicles classification. Therefore, packing technology is required previous to installation. The additional glass fiber-reinforced glass (GFRP) materials have been extensively used by civil engineers as a 14-point steel replacement, and FBG can be manufactured in any way.

Effective to improve the accuracy of the transport application. Bragg's "service line" is a low frequency or efficient input coil and / or an effective reflector for optical waveguide In FBG routing systems, energy mixing is available between different forms of propagation and propagation after fiber. Operation is a very powerful process. The Bragg grating can reflect the wavelengths of a more specific or broad range, and as the distance passes All other light, which is the angle of the horizontal or vertical, is absorbed into the line. the optical fiber distribution of a solid model with an occasional or periodic distribution, the contiguous group is based on the basis of the university. The answer is an industrial table taken from 'optical fiber. As a result, Bragg gratings become the most selective spatial reflection in the core. Optical sensors bottom on Bragg gratings have been used in many companies [18]. There are many types of Bragg gratings, such as conventional Bragg grays, Bragg flames and Bragg gratings. These Bragg grates are made up of many different lines between the edges or the corners between the plates and the fiber axis. The most common Bragg face with fibers is a reflective Bragg compressor. The cut-off line has a distortion of the fiber axis, that is, the angle between the area and the fiber axis is less than 90 °. The spindle has a long distance. The distance between Greek eagles increases

III LITERATURE REVIEW

M.I. Skvortsov et.al.[1] The application of femtosecond recording technology enables the creation of Bragg grate fibers (FBGs) in various forms of multifunctional fibers into laser beams. In this article, we introduce the different configurations of two-core Raman lasers. Compared to existing solutions, the internal FBG is used in dual-core optical fiber corners, which can reduce laser excitation and improve the power generation efficiency.

Riyadh et.al.[2] Low-speed fiber optics for soft reflection in Bragg fiber (CFBG), which is inscribed in 5-foot-high-fiber fibers and incorporates high performance with CFBG separating cables from semi-open type. through a 980 nm laser pump, the most common laser light can be emitted with a single output of 4.3 mW and a incline efficiency of 11.2%.

Shun Wang et.al.[3] The Fiber Bragg Gratings (FBG) are engraved into seven base cables with laser-guided femtosecond light. Various peaks in the balance and transport of vision were followed, which were triggered by Bragg's rise to the basics and labeling under the appropriate conditions of the process. The sample size shows a linear response to global warming and understands 12 pm / ° C between room temperature and 1000 ° C. This Bragg gradient is expected to apply in a harsh environment

Martin Becker et.al.[4] The Fiber Bragg Grating (FBG) is covered in a body of stainless steel silicone that has been engraved through the interference and sources of deep ultraviolet laser light. The objective fibers are pure silica, contain no do pants, and have not been treat through hydrogen previous to grinding. The technique is suitable for measuring the specificity of the optical fiber domain, and allows for limiting the limitations of the guidance method. Application of this type of FBG is possible, especially in the field of fiber optics.

Qiang Liu et.al.[5] Fiber optic sensors based on cascaded bragg (ECFBG) and fiber Bragg graping (SMFBG) are provided and validated experimentally, able to compensate for axial and axial loading. The ECFBG is sensitive to shear and shear stress, while the SMFBG is less sensitive but sensitive to axial axons. The lowest inclination of the ECFBG at 0 ° and 180 ° inclination directions was 36 pm / m-1 pm and -37 pm / m-1. The heat sensitivity of ECFBG and SMFBG was 0.76 pm / εε and 0.72 pm / εε, correspondingly.

Zheng Guangjun et.al.[6] presented a series of refactory optical sensors and validated them in their experiments. It is based on a Bragg grating screw (TFBG) mounted on the base fiber, which is lowered from the bottom for conventional model fiber (SMF). Because the cores do not differentiate between the SMF and the fine fibers, the model needs to be retrofitted in the SMF. The sensor can be used to detect changes in refignive index (SRI) around the environment. In addition, the sensor can solve the problem of reduction in SRI and temperature.

Jianguan Tang et.al.[7] proposed and experimented with a low-frequency acoustic detection system (DAS) with ASE and Michelson interferometer, based on a series of high-frequency Bragg (UW-FBG) spectra. investigational consequences demonstrate that the proposed system has better sonic performance than conventional hydrophones.

Jianfeng Chen et.al.[8] provided a network of diffusers with a high frequency of Bragg's high-frequency compressors, and validated the experiments. The network is based on Multiplexing technology (TDM). We use interferometer matching the path to obtain the disturbance signal, and then we can use 3 × 3 passive demographic technology to distribute the amplitude, phase, frequency and location information from the interference signal. It performs experiments to identify traffic pipes in the road, a piezoelectric transducer (PZT), and a water tunnel that is guided by a signal generator. Experimental results show that this system is capable of completely eliminating the signal of the channel and the water acoustic signal produced by the PZT, and its frequency response is between 50Hz and 800Hz.

Jing Kong et.al.[6] has introduced a new series of high-speed heterogeneous accelerators (DPAMCFs), which are approximately two angles close together, and will gradually change in size. The models in the DPAMCF are composed of two super groups, which can be combined into two heterogeneous sections. The two super modules are infinite, and the crosstalk between them is expelled. Fiber Bragg Gratings (FBG) were well engraved in the DPAMCF, and each axial reading angle and temperature were measured. The proposed DPAMCF provides a platform for integrating an FBG unit with two different Bragg lines in a plane in a parallel position.

Lin Wang et.al.[9] Currently, due to "size matching issues," describes the discrepancy between the nature of a "dimensional" measurement of grater sensor and "multi-dimensional" processing of the gradient something to measure. Bragg fiber development is used to identify. The frustration of grinding homemade rice is already difficult. To address this problem, new types of sensors have been developed. These sensors are based on compliance mechanics and Bragg's grinding technology, which is sensitive to damage correction detection. To detect different stresses, it is possible to design different methods, depending on how they are applied to the Greek Bragg grille. In addition, we create different mathematical models based on the geometric properties of the mixed mechanics. Next, based on the principle of bragg sensing regulation, a model of fitness for practical applications of spatial deformation sensors. Based on the ideas mentioned above, this paper has successfully experimented with realizing spatial variation and achieving its goals.

IV METHODOLOGY

Techniques commonly used in laser semiconductor propagation that can be used to adjust the transmission spectra to specific requirements. This technique involves the introduction of a phase transfer between glass fibers, which can be adjusted by location and size to form a specific transfer spectrum. One of the obvious applications is the production of cable lighting and narrow band lighting. In addition, different section rotations can be incorporated to produce other groups, such as comb filters. It can also be used for single function DFB fibers.

The bragg operation has a low loss and is compatible with the existing fibers of the telecommunication network. Bragg grinding enables the production of high-performance optics at high speeds at low cost. Optical fiber optics creates a relatively simple, easy-to-use concept, prepared principle of the FBG sensor Hill et al. We first established the configuration of FBG with optical fiber. It was performed in the Canadian Communications Research Center (CRC) The Bragg wavelength is caused by the light reflected by the change in the annular current, as shown in Figure 1, which can be interpreted as

$$\lambda = 2n\Lambda$$

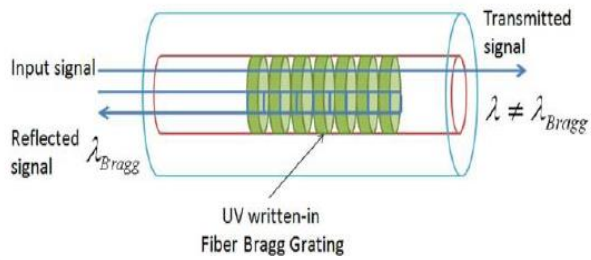

Fig. 2. The operational principle of a FBG sensor.

Where is the FBG's effective reflective index and grating periodicity of the FBG. Appropriate to temperature and strain dependence of the grating period, the Bragg plate varies with the Te and volt ε temperatures. General comments on the relation of the load angle among the FBG sensor and the temperature sensor may be stated

$$\frac{\Delta\lambda_1}{\lambda_1} = \frac{\Delta\lambda_\varepsilon}{\lambda_\varepsilon} + \frac{\Delta\lambda_{Te}}{\lambda_{Te}} = (1-P_e)\varepsilon + (\alpha+\gamma)\Delta T_e$$

$$\frac{\Delta\lambda_2}{\lambda_2} = \frac{\Delta\lambda_{Te}}{\lambda_{Te}} = (\alpha+\gamma)\Delta T_e$$

Among them, Pe and Pe are respectively the thermal expansion coefficient, thermo-optical coefficient and photo-elastic coefficient of the optical fiber. Therefore, the sensor load can be designed through subtract 1equation from 2 equation [4]

$$\varepsilon = \frac{1}{(1-P_e)}\left(\frac{\Delta\lambda_1}{\lambda_1} - \frac{\Delta\lambda_2}{\lambda_2}\right)$$

Because the load on the sidewalk is straight connected to the vehicle weight P on the sidewalk, FBG sensors can be used to categorize vehicles

3D GFRP-FBG sensor because the FBG sensor is completed of glass fiber and cannot be inserted directly into the sidewall, these learn uses a GFRP device to control the FBG sensor. In calculation, the 3D GFRP-FBG sensor will be developed [19]this has been selected as a unit sensor to achieve a three-dimensional (3D) valve distribution across the width of the street, resulting in a more accurate classification of vehicles. The geometric intend of the GFRP-FBG 3D sensor consists of three sections: one to the horizontal, transverse directions and one to the side. The short-gauged element of the sensor proposes to sense the vertical strain whereas the long-gauged part used to distinguish the longitudinal and transverse strains. When the external load is applied to the 3D GFRP FBG sensor, the length changes the load, and the FBG is built up which the load can detect. It seems that the 3D GFRP-FBG sequences can be able to withstand the harsh environment of pavement can be construction by embedment process. This sensor can be to accurately evaluate the weight of the vehicle

Sensor Networks: Vehicle sensing systems require multiple sensor networks within the pavements for data collections. Classification of vehicles, correct estimates are required. Consequently, a sensor network with high speed estimation is desirable to build a successful system. The number, location and distance between sensors are the most important factors affecting the sensor network. In organize to accurately calculate the speed of the vehicles and the wheels for classification, both sensors should be

integrated into the network. These criticisms must be placed under the wheel path to achieve the highest possible sensitivity . In the vehicle control panel and vehicles classification, the optimum distance between the two lanes is usually between 2.13 m (7 feet) and 6.1 m (20 feet) Similarly, changes caused by the placement of the wrong sensor (D distance of the parallel sensor) will be result in significant mistake in the speed estimation.. To mitigate this failure of the transport system, the distance of the sensor must be large enough to achieve the highest speed for vehicles classification.

V VEHICLE CLASSIFICATION

To categorize passing vehicle, an implanted system of sensors within the pavements determination require to specify the numeral of axes, axial speeds and speed of passing vehicles. When a wheel crosses the road, the road will generate speed, and the built-in GFRP-FBG sensor will also generate a load signal.

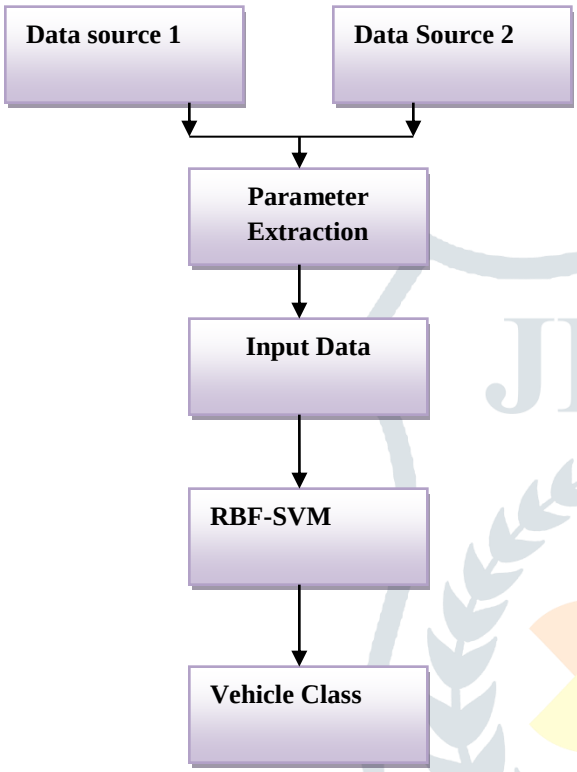

Fig. 3 proposed flow chart

It can be seen from Equation 4 that the change in load on the FBG sensor will result in a Bragg tax change that is observable, and can be checked and adjusted to obtain the critical information in the boundary. Route. Therefore, all information on the classification of vehicles, including the number of axes and wheels, is strictly correlated with the load caused by the vehicle traveling on the sidewalk. To address the problem of vehicles classification, this paper uses a MATLAB check box to solve the branding problem. The use of the support vector machine must split the together data into two sets, as well as the training data used to train the recording scheme and the experiment series used to corroborate the trained classification representation. It is significant to prefer the right function from the deception to provide data in the entry space to the main work area. There are numerous basic categories of functions, together with linear, polynomial, sigmoid, and radial function (RBF). The reason for choosing the RBF in this study is that the RBF randomization was entered at a higher level, so that non-linear analysis is possible because multiple sources can provide better performance and produce greater accuracy, this strategy uses a centralized strategy, as shown in Figure 1. Strategies collect data from sources in the data and compile it. Those to create an input file, which creates an input file. The simulations of modularity in previous studies have shown that longitudinal components have the highest sensitivity to measuring heavy weigh-in motion (WIM), followed by vertical components. To check if the component and stand-alone elements of the 3D sensor can be used for vehicles classification, the 3D-1 sensor stand and the 3D-2 sensor stand are used to provide Vehicles classification.

VI. CONCLUSION

In this study, SVM classification algorithms (OAA and OAO) will be used in different categories. to estimated performance of the vehicles based on the ODL algorithm. Recent advances in the field of small, lightweight optical fiber and EMI have led to new types of traffic patterns. Fiber Bragg Grating Sensors (FBG) is used for vehicle classification. Sensor networks consisting of two FBG

sensors have been developed to eliminate the number of axes and axial distances. Specifically, when the vehicle is driving on the road, the FBG file captures the input signal produced by the sidewalk to use a top to identify features. With two sensors, you can measure the speed of the vehicles and the steering wheel and classification accuracy will be high due simple vehicle classification technique will be followed by SVM classifier

REFERENCES

M.I. Skvortsov I.A. Lobach S.R. Abdullina A.A. Wolf A.V. Dostovalov ; A.A. Vlasov S. Wabnitz S.A. Babin Raman fiber laser based on dual-core fiber with fiber Bragg grating inscribed by femto second radiation 2018 International Conference Laser Optics (ICLO) 2018

Riyadh Khlf Ahmed Khalil I. Hajim 2018 Al-Mansour Half-open cavity random fiber laser based on chirped-fiber Bragg grating array written in erbium-doped fiber International Conference on New Trends in Computing, Communication, and Information Technology (NTCCIT) 2018

Shun Wang Fiber Bragg grating in seven core fiber fabricated with infrared femtosecond laser pulses and a phase mask : 2019 18th International Conference on Optical Communications and Networks (ICOCN) 19257691 10.1109/ICOCN.2019.8934361 IEEE

Martin Becker Luis Fernandes Manfred Rothhardt Sven Bruckner Kay Schuster Jens Kobelke Orlando Frazao ; Hartmut Bartelt Paulo V. S. Marques Inscription of Fiber Bragg Grating Arrays in Pure Silica Suspended Core Fibers 2009 | Volume: 21, Issue: 19 IEEE

Qiang Liu Quan Chai Ye Tian YanShuang Zhao Yanlei Liu Song Wang JianZhong Zhang Jun Yang LiBo Yuan Spectral characteristics of rotated fused polarization maintaining fiber Bragg gratings subjected to transverse loading 2017 25th Optical Fiber Sensors Conference (OFS)

Guangjun Zheng Yunqi Liu Lei Shi ; Runhan Zhao Tingyun Wang Reflective index sensors based ontilted fiber Bragg grating inscribed in the thin-core fiber 2016 15th International Conference on Optical Communications and Networks (ICOCN) 2016 IEEE

Jianguan Tang Liang Li Huiyong Guo Haihu Yu Hongqiao Wen Minghong Yang Distributed acoustic sensing system based on continuous wide-band ultra-weak fiber Bragg grating array 2017 25th Optical Fiber Sensors Conference (OFS)

Jianfeng Chen ;Yunqi Liu Tongjian Cai Tingyun Wang Fiber laser sensor based on fiber-Bragg-grating Fabry-Perot cavity Asia Communications and Photonics Conference and Exhibition IEEE: 2010

Jing Kong Xiaowei Ouyang Ai Zhou Libo Yuan Simultaneous strain and directional bending sensor based on eccentric-core fiber Bragg grating 2017 25th Optical Fiber Sensors Conference (OFS)

Lin Wang Xudong Wang Minggui Wan Yuan Cao Xinhuan Feng Bai-ou Guan Wavelength-swept fiber laser based on linear chirped fiber Bragg gratings 2017 16th International Conference on Optical Communications and Networks (ICOCN) IEEE 2017

L.E.Y. Mimbela, L. A. Klein, “Summary of vehicle detection and surveillance technologies used in intelligent transportation systems “2000

P. G. Michalopoulos, “Vehicle Detection Video Through Image Processing: The Autoscope System,” IEEE Transactions on Vehicular Technology, vol. 40, no. 1, pp. 21–29, 1991.

A. Y. Nooralahiyan, H. R. Kirby, and D. McKeown, “Vehicle classification by acoustic signature,” Mathematical and Computer Modelling, vol. 27, no. 9–11, pp. 205–214, 1998.

A. Arora, P. Dutta, S. Bapat, V. Kulathumani, H. Zhang, V. Naik, V. Mittal, H. Cao, M. Demirbas, M. Gouda, Y. Choi, T. Herman, S. Kulkarni, U. Arumugam, M. Nesterenko, A. Vora, and M. Miyashita, “A line in the sand: A wireless sensor network for target detection, classification, and tracking,” Computer Networks, vol. 46, no. 5, pp. 605–634, 2004.

EUROCAST, 2009, pp. 391–397. \Y. K. Ki and D. K. Baik, “Vehicle-classification algorithm for single-loopdetectors using neural networks,” IEEE Transactions on Vehicular Technology, vol. 55, no. 6, pp. 1704–1711, 2006.

C. Sun, S. G. Ritchie, and S. Oh, “InductiveClassifying Artificial Network for Vehicle Type Categorization,” Computer-Aided Civil and Infrastructure Engineering, vol. 18, no. 3, pp. 161–172, May 2003.

S. Cheung, S. Coleri, B. Dundar, S. Ganesh, C.-W. Tan, and P. Varaiya, “Traffic Measurement and Vehicle Classification with Single Magnetic Sensor,” Transportation Research Record, vol. 1917, no. January, pp. 173–181, 2005.

S. Cheung, “Traffic Surveillance by Wireless Sensor Networks : Final Report,” California Path Program Institute of Transportation Studies University of California,Berkeley, vol. 1, no. January, p. 161, 2007.

R. B. Malla, A. Sen, and N. W. Garrick, “A Special Fiber Optic Sensor for Measuring Wheel Loads of Vehicles on Highways,” Sensors, vol. 8, no. 4, pp. 2551–2568, Apr. 2008.

K. O. Hill and G. Meltz, “Fiber Bragg grating technology fundamentals and overview,” Journal of Lightwave Technology, vol. 15, no. 8, pp. 1263–1276, 1997.

M. Majumder, T. K. Gangopadhyay, A. K. Chakraborty, K. Dasgupta, and D. K. Bhattacharya, “Fibre Bragg gratings in structural health monitoring-Present status and applications,” Sensors and Actuators, A: Physical, vol. 147, no. 1, pp. 150–164, 2008.

B. Lee, “Review of the present status of optical fiber sensors,” Optical Fiber Technology, vol. 9, no. 2, pp. 57–79, Apr. 2003.