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HYDROCARBON SENSING FOR ENVIRONMENTAL MONITORING USING INTERNET OF THINGS

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Abstract:

The Internet of Things (IoT) focuses in particular to solve major problems for our climate, manufacturing, urban, domicile and community by gathering, combining and processing information from a large number of devices and sensors. We suggest a new IoT approach in order to track hydrocarbon emissions from retail fuels in real time. Our approach involves a cheap yet high-precision fibreoptic sensor, which can quickly locate hydrocarbons in groundwater and can be installed in existing wells. Thesedetectors for hydrocarbon are the main elements in an IoT system fsor data gathering and study using commercially accessible cloud system for low power communications (e.g. LORA). This latest IoT platform, integrating the detection of hydrocarbons with data storage using cloud, can be detected and reported in real time to build up-to-date cartoons and warnings for hydrocarbon emissions.The platform will capture hydrocarbon emissions at millions of sensors at many of the service centersall over the world and involuntarily produce modified maps of pollution and associated warnings for each service center, business chain and the body monitoring the environment in the cloud.

Key Words: Hydrocarbon Sensing, Internet of Things, PollutionMonitoring, Smart Cities

Introduction:

In the second half of the 19th century, the invention of the internal combustion engine revolutionized the global transport market, but it raised a variety of problems for hydrocarbon emissions. Gas emissions during pumping, storing and transportation of fuel contribute to contamination of hydrocarbons. The most frequent form of hydrocarbon exposure occurs with underground leakage fuel tanks in retail pumping units (e.g. gas stations). The latest approach is to construct groundwater testing wells from tank stock and other oil supplies for the identification of fuel leaks in retail outlets. In the medium-sized supermarket fuel outlet with six tanks at least 24 such testing wells would typically occur across all subway tanks, and (four refueling bays). In addition, hundreds of thousands of retail fuel dealers worldwide are also available for each district. Established hydrocarbon sensors and tracking systems are much too costly to introduce at a rate of ten thousand dollars. On the other hand, hydrocarbon emissions will unless found sooner, cause major healing issues and the clean-up is very expensive. In Australia, for instance, there are more than 6,300 petrol stations and other hydrocarbons [2]. In recent years, high concentrations of benzine, a carcinogenic agent was found from a station under a waterfront park in an indoor home in close proximity with high concentrations of toxic chemical mixes [2].Such emissions of hydrocarbons can have an effect in other nearby homes, including at the Sydney Water Reservoir [2]. The current approach for the monitoring at acceptable expense of service station-induced emissions of hydrocarbons is to conduct water sample inspections manually taken multiple times a year from water monitoring wells. That requires the dispatch of water inspectors into each service station to gather and search for hydrocarbon emissions from all sampling wells at any monitoring venue. Besides being costly, manual inspection is susceptible to errors and its low frequency can result in lack of micro-discharge and related accidents, which slowly cause pollution.

In this paper we deal with all of these problems with the implementation of a real-time hydrocarbon sensing approach based on Internet of Things (IoT):

- A modern, very cost-efficient hydrocarbon sensor can reliably detect hydrocarbons and recover from many contamination events for identification of water.
- The IoT network enables the automated calibration of emission levels of hydrocarbons from millions of such sensors and offers map updates and associatedwarnings for individual centers, business offices and regional governments immediately. It offers robust expansion for intake of data from many systems to detect hydrocarbonsestablished at numerous stations, an efficient wireless networking platform for transmission of sensor data over a multi-kilometer period, sensor data storage capability and sensor meta data.

Besides 24x7 surveillance of hydrocarbon emissions, it does not cost more than manual inspection to put in and manage this IoT-based hydrocarbon solution.

IOT-Based Hydrocarbon Sensing Platform:

The Hydrocarbon Sensing IoT (HCS IoT) components and functionalities are given in this section. HCS IoT is the primary aspect of this process, and consists of a broad set of applications: 1) IoT detector to sense hydrocarbons, 2) Sensor Node for IoT, 3) Portal for IoT, 4) communication network, 5) cloud for data storage and processing, 5) warning system and console, and finally 6) user interface, to view data gathered in real time. Individual detectors and sensor nodes will be located in every groundwater well and will detect and send the information via the IoT gateway to the Internet. A mixture of Lora and Wi-Fi networks is used in this article. The Amazon EC2 service implements the cloud system and console [3].

A. Hydrocarbon Sensor Structure:

The hydrocarbon detector used here is intended to recognizegas leakage at smart retail fuel outlets in the ground water surveillance wells. The detecting feature of the detector is a single fiber optic mode, which is attached with a Kevlar® [4] thread to a silicone polymerized rod. Silastic® E RTV Silicone Rubber [5] is the silicone material used in this article. We have combined the silicone base with the Silastic® curing agent at a rate of 10:1 for silicone-coated rod preparation and slowly passed through a

20 cm of optical fibre with hard coating. Then the rods were hanged into a smoker hood for 24 hours to repair. A single-mode fibre optic (1550nm working wavelength, SMF-27, Corning) was later used for loosely wood-coated rod wrapping Kevlar® [4] thread.

B. Sensing Method:

Where a relatively small curvature radius transforms an optical fibre, some directional light is produced by the heart and the cover. This limits the fibre propagation of optical power. Light propagation through the optical fiber is affected by two types of bending, namely micro-bending and macro-bending [6]–[9]. A limited fibre area with a fibre curvature of less than 2 mm inside radius is obtained from microbending [10]. Macro bending is a relatively broad curve in the fibre which can lead to a larger loss of light distribution. HCS IoT has used the optic fibre sensor in one mode to detect hydrocarbons by swelling the silicone-coated strip to produce a micro filter. The incorporation of the fuel into the polyp matrix of the silicone-coated rod would help to extend volumetrically in the case of hydrocarbon exposure [11]. The expansion creates a pressure which is transmitted to the optical fibre via Kevlar® yarn, thus causing the optical fibers to bend. The micro bending induced attenuation (γ) in optical fibers is increased, as seen in [6], [12], [13], by:

$$\gamma = N\langle h^2\rangle \frac{a^4}{b^6\Delta}\left(\frac{E}{E_F}\right)^{3/2} \qquad (1)$$

Where N is the number of bumps formed by expansion of silicone, the bumps' height shall be as high as h[1], b shall be the total diameter of the fibre, and ‘a’ is the core radius, E_f and E shall be elastic modules of fibersurrounding material and of fibers as defined in [13], and Δ is fiber refractive index (1.444 at 1500 nm).As is seen in Eq. 1, bumps may have an effect on the total transfer loss because of micro-bending by the amount and height average. We wrap the Kevlar® helically to generate bumps along the optical fibre, which have an average distance of 1 mm.

C. Experimental Lab Test:

A measuring device consisting of a low voltage, compact diode laser and optical power meter (Newport Power meter[2]) has been developed to measure the loss of transmission resulting from a microbending in our experimental laboratory scenarios. The sensor was cut in half and the sensor separated to one of the half patch cords to connect the sensor to the laser source. A fibre can be directly linked to the power meter coupler on the power meter line. When in contact with clear water and a mixture of water and fuel, the sensitivity of the sensor mounting has been tested. 91 unleaded fuels were used in the tests [14]. The laser light was attached to a sensor rod by the optical fibre. The power meter at the other end of the optical fibre measured the emitted light. A decrease in the strength, calculated as power by the micro-bending in microwatts, was observed through fibre (μW). Data obtained in three separate terms from the power meter with the sensor:

- Until fuel exposure in pure water;
- Water (Sensing) during exposure to fuel;
- Regeneration after fuel evaporation.

The findings show a positive feeling and strong reaction to the injection of the fuel and a quick recovery as soon as the fuel has evaporated. The optical power meter can also be replaced by cheaper alternatives including optical power meters compliant with Arduino[3] as used in real groundwater testing wells [15].

Literature Review:

Study projects like [16]-[20] have suggested the use of polymer materials to track liquid hydrocarbons as related approaches to this article. None of these articles, however, took into account the benefit of using IoT-based sensors. Moreover the scalability and cost of the technologies were not taken into account. The authors proposed in [19] a quasi-distributed fibre optic bending sensor to detect the oil hydrocarbon leak using a clear optical frequency field. The authors have shown that in an 8-minute period of 20 cm, the sensor proposed can detect petrol. Buerck et al. [18] proposed that an evanescent field absorption system be used to track aromatic hydrocarbons from contaminated groundwater in almost-infrared water with a quartz glass fibre protected by hydrophobial silicone membrane (NIR). [21] The authors used a corresponding procedure, which focuses on optical time-domain (OTDR) reflectometry by providing a chemical sensor fibre-optic detection and location for hydrocarbon leakage. A distributed fibre optic sensor based on OTDR and a polymer sheet of a similar kind to the one used in this article, was proposed by MacLean et al. [16] and [17] in order to detect hydrocarbon fuel waste. However the multi-parameter OTDR approach [22], [23] is very costly and does not inherently support large-scale IoT applications.

Conclusion:

Continuous, real-time sensing of hydrocarbons is one of the most significant fuel storage problems, as the leaks will lead to costly leakage and contamination. This article describes an IoT sensing hydrocarbon that is capable of coping economically with this issue.

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References:

1. ACAPMA, “iscan 2016 - an overview of the Australian retail fuelsmarket,” Australasian Convenience & Petroleum Marketers AssociationReport, 2016.
2. N. Hasham, “Hundreds of petrol stations leaking fuel,” Jan 2012. [Online]. Available: https://www.smh.com.au/environment/hundreds-ofpetrol-stations-leaking-fuel-20120104-1plam.html

3. I. Amazon Web Services, “Amazon elastic compute cloud (Amazonec2),” 2019. [Online]. Available: https://aws.amazon.com/ec2/
4. H. H. Yang and H. H. Yang, Kevlar Aramid Fiber. Wiley, 1993.
5. “Silastic rtv-4230-e silicone rubber,” 2017. [Online]. Available:https://consumer.dow.com
6. J. A. Jay, “An overview of macro bending and micro bending of optical fibers,” White paper of Corning, pp. 1–21, 2010.
7. W. B. Gardner, “Micro bending loss in optical fibers,” The Bell SystemTechnical Journal, vol. 54, no. 2, pp. 457–465, 1975.
8. K. Petermann, “Fundamental mode micro bending loss in graded-index and w fibres,” Optical and Quantum Electronics, vol. 9, no. 2, pp. 167–175, 1977.
9. W. A. Gambling, H. Matsumura, and C. M. Ragdale, “Curvature and micro bending losses in single-mode optical fibres,” Optical and Quantum Electronics, vol. 11, no. 1, pp. 43–59, 1979.
10. J. Laferriere, G. Lietaert, R. Taws, and S. Wolszczok, Reference Guideto Fiber Optic Testing. JDS Uniphase Corporation, 2007.
11. S.-E. Silicone, “Characteristic properties of silicone rubber compounds,”Silicone, Shin-Etsu, 2012.
12. R. Olshansky, “Distortion losses in cabled optical fibers,” Applied Optics, Vol. 14, no. 1, pp. 20–21, 1975.
13. W. Griffioen, Optical Fiber Mechanical Reliability. Technische Universiteit Eindhoven, 1995.
14. “Shell unleaded 91 petrol,” Aug 2016. [Online]. Available:https://www.shell.com.au/motorists/shell-fuels/sds-tds
15. “Optical power meter (with sfp and ddm protocol),” Aug 2016. [Online]. Available: https://hackaday.io/project/21599-optical-power-meter-withsfp-and-ddm-protocol
16. A. MacLean, C. Moran, W. Johnstone, B. Culshaw, D. Marsh, andP. Parker, “Detection of hydrocarbon fuel spills using a distributed fibreoptic sensor,” Sensors and Actuators A: Physical, vol. 109, no. 1-2, pp.60–67, 2003.
17. MacLean, J. McCormack, and B. Culshaw, “Distributed sensing for liquid leaks and spills,” in Fiber Optic Sensors and Applications VII, Vol. 7677. Int. Society for Optics and Photonics, 2010, p. 767703.
18. J. Buerck, S. Roth, K. Kraemer, M. Scholz, and N. Klaas, “Application of a fiber-optic nir-efa sensor system for in situ monitoring of aromatichydrocarbons in contaminated groundwater,” Journal of HazardousMaterials, vol. 83, no. 1-2, pp. 11–28, 2001.
19. R. Lopez, V. Spirin, M. G. Shlyagin, S. V. Miridonov, G. Beltran,E. A. Kuzin, and A. M. Lucero, “Coherent optical frequency domainreflectometry for interrogation of bend-based fiber optic hydrocarbonsensors,” Optical Fiber Technology, vol. 1, no. 10, pp. 79–90, 2004.
20. O. S. Wolfbeis, “Fiber-optic chemical sensors and biosensors,” AnalyticalChemistry, vol. 80, no. 12, pp. 4269–4283, 2008.
21. J. Buerck, S. Roth, K. Kraemer, and H. Mathieu, “Otdr fiber-optical chemical sensor system for detection and location of hydrocarbonleakage,” Journal of Hazardous Materials, vol. 102, no. 1, pp. 13–28, 2003.
22. E. Sinchenko, W. E. K. Gibbs, A. P. Mazzolini, and P. R. Stoddart, “Effect of cladding refractive index on a quasi-distributed optical fibrechemical sensor,” J. Lightwave Technol., vol. 31, no. 20, pp. 3251–3257,2013.
23. P. R. Stoddart, P. J. Cadusch, J. B. Pearce, D. Vukovic, C. R. Nagarajah, and D. J. Booth, “Fibre optic distributed temperature sensor with anintegrated background correction function,” Meas. Sci. Technol., vol. 16, pp. 1299–1304, 2005.