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SENSOR NETWORK WITH ENERGY EFFICIENT AND LOW-COST GAS SENSOR NODES FOR THE DETECTION OF HAZARDOUS SUBSTANCES IN THE EVENT OF A DISASTER

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Abstract: This paper provides details regarding energy productive and minimal expense gas sensor hubs for spatially settled, exact gas estimations in case of a catastrophe. This is accomplished by the reconciliation of different minimal expense and low-power sensors for gas, temperature and stickiness joined with insightful sign handling and data combination. The overall situation of the sensor hubs is expected to play out a spatially settled gas estimation. For this, a minimal expense restriction framework for the overall situating of the sensor hubs is executed. A guide can be made, where spatially settled gas fixations and the gas sources can be shown.

Keywords: wireless sensor network, sensor fusion, indoor environment, microsensor, gas detectors.

I.INTRODUCTION

In case of a catastrophe, it is critical to rapidly get an outline of the danger circumstance. This is still mostly an errand of the salvage faculty - with relating hazards. The main errands are the quest for casualties and wellsprings of threat. Salvage staff hazard their lives, and at times a mission of this sort is incomprehensible. Every catastrophe is special and eccentric. The salvage staff and their instruments request a serious level of adaptability. For instance, after a tremor a definitive objective is to help individuals as fast as could really be expected. The salvage work force will require a fast outline of the harm: Are there hazardous gases? Where are fires? Where are the casualties covered under garbage? Today, robots and sensors are now utilized in segregated cases to explain the circumstance at the location of a crisis and to determine measures. Fraunhofer analysts from different orders are dealing with such robots and self-ruling sensor networks so the circumstance can be evaluated rapidly and productively.

An organization with sensor hubs planned for crises should be pretty much as practical as conceivable to appropriate a huge number of sensors in the influenced territory. Every sensor hub should cost under 100 euros. So numerous sensor units can be set in a specific region. For the examination of a space of 1000m2, up to 25 sensor hubs are required relying upon the ideal goal. In this work, we report on the advancement of minimal expense, energy-productive, battery-fueled sensor hubs, equipped for identifying harmful and dangerous gases. It should be guaranteed that the hubs in the pre-owned period (for example a couple of days) are energy independent. The framework means to play out a spatially settled gas estimation, in which the sensor hubs can find themselves. The sensor network intertwines the data of the individual sensors and connections them with one another for assessment. The outcome is a guide wherein the gas focuses are spatially settled and the situation of the gas source is appeared.

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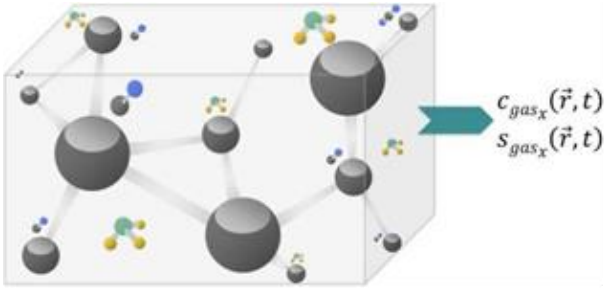

Fig 1; Schematic illustration of the gas sensor network for spatially resolved measurement of gases in the disaster environment with the gas concentration cgas(.) and the gas source sgas(.).

II.SYSTEM DESIGN

The created sensor hub named Sniff Node is an energy-proficient and minimal expense framework to gauge gases just as temperature and mugginess. For this reason, minimal expense and low-power sensors are utilized. The general situation of the sensor hubs are expected to play out a spatially settled gas estimation. Therefore, the framework has a ultrasonic transmitter and a recipient to get the distance between the hubs by ultrasonic season of-flight estimations.

The critical segment of the framework is the 32-bit contradicting message microcontroller PSoC5 with ARM Cortex-M3. The benefit of this regulator is that there are simple and advanced fringe works that can be customized independently. Notwithstanding the computerized signal handling, practically all simple sign preparing steps are executed in the regulator. To save energy just essential circuits might be enacted and superfluous circuits can be incapacitated. The correspondence by means of ZigBee with other sensor hubs and the climate is finished with the Anaren A2530 ZigBee module. The following sensors are implemented in the system and connected to the PSoC controller:

Metal oxide gas sensor (MOX) from Applied Sensor
colorimetric gas sensor developed by Fraunhofer IPM
humidity and temperature sensor SHT 15 from Sens Irion
three-axis digital compass HMC5883L from Honeywell
acceleration sensor LIS331DLH from ST Microelectronics
four ultrasonic transmitters
four ultrasonic receivers

The speed increase sensor is associated with the regulator to show whether the sensor hub is being moved. Provided that this is true, measures can be started to find the framework once more. The temperature and moistness sensor and the compass are associated by means of I2C transport, the speed increase sensor through SPI transport and any remaining sensors are associated simple to the PSoC regulator.

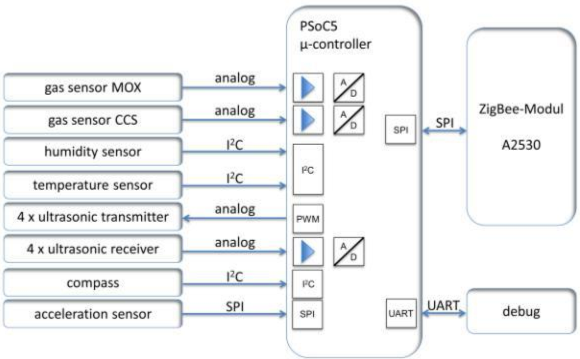

Fig. 2 shows the block circuit diagram of the sensor node Sniff Node.

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III.GAS DETECTION

The prerequisites for a gas sensor for the portrayed application executed on battery-controlled sensor hubs are energy-productivity, low value, power, high selectivity and quick sensor reaction. The precision ought to be adequate to gauge the danger circumstance.

For sensor networks metal oxide sensors are frequently utilized and furthermore in this framework. These sensors are economical yet have absence of selectivity. A metal oxide gas sensor reacts to an assortment of gases, hence it is hard to offer a precise expression about which gas was distinguished. For this framework another estimation technique is utilized to expand the selectivity: a shading changing gas sensor dependent on the colorimetric estimation guideline. This sensor is an optical sensor. The shade of a receptive layer on a photodiode changes because of a substance response. A LED illuminates the photodiode, on which the receptive layer is straightforwardly kept. The power of light on the photodiode relies upon the grouping of the objective gas. The signs coming about because of the photodiode are enhanced by a lock-in speaker carried out in the regulator. However the colorimetric materials are delayed in their response to the objective gas contrasted with MOX sensors, and the gauge of the sensor isn't steady. It is beyond the realm of imagination to expect to make quantitative estimations yet the sensor gives data on which gas is available. For additional sign handling steps we assess the prompt sign change in the early assimilation stage rather than the harmony. The responsive layer is exceptionally particular, and there are different materials relying on which gas is to be estimated.

To remunerate the drawbacks of each gas sensor (absence of selectivity of the metal oxide sensor and moderate response and temperamental standard of the colorimetric sensor) we intertwine the sensor information with a counterfeit neural organization, a variety of a repetitive organization. The organization with an information layer, two secret layers, a yield layer and a setting layer is prepared to yield the separate gas fixations from the approaching sensor signals. The neurons of the second secret layer, sigma-pi neurons, will be neurons of higher request.

This mix of two distinct gas sensors and the ensuing information combination bring about a practical and strong estimation strategy for various gases for instance carbon monoxide, nitrogen dioxide or alkali.

IV.LOCALIZATION WITH ULTRASONIC TIME-OF-FLIGHT MEASUREMENTS

To make a spatially resolved gas measurement with the gas sensor network, the relative positions of the sensor nodes are necessary. After the sensor nodes are deployed in the field, the position to each other must be determined. For low-cost localization, each node has ultrasonic transmitter and ultrasonic receiver. In the measuring procedure are always two sensor nodes active (Fig. 3).

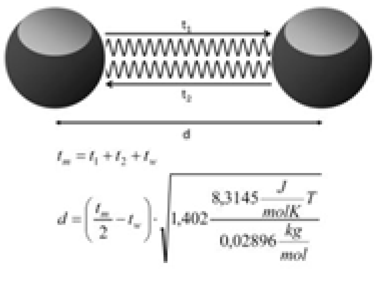

Fig. 3. The left node sends out an ultrasonic signal (time t1). This signal is received by the second active node and after a short wait (tw) it returns a signal (time t2).

One node sends out an ultrasonic pulse. This signal is received by the second active node and after a short wait it returns a signal. The short waiting time is needed to distinguish from the returned signal and reflections. The signal propagation time is dependent on the ambient temperature and the distance between the sensor nodes. The temperature is also measured and the distance can be calculated.

Fig. 4 shows a distance measurement up to 5m. The statistical error from 10 measurements per distance is in the millimeter range. The systematic error results from the temperature measurement, but it can be corrected with a corresponding calibration.

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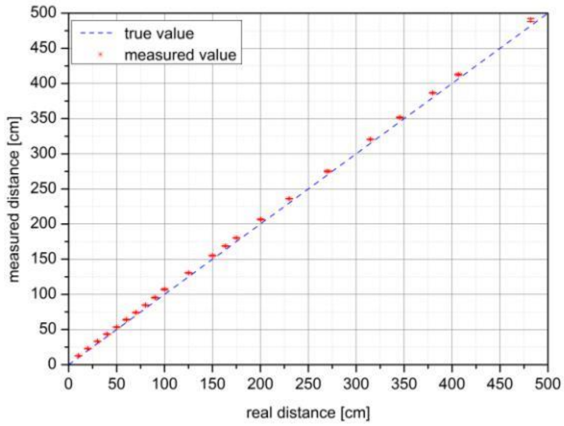

Fig. 4. Distance measurement up to 5m.

The red dots are the measured values and the blue line is the true distance. There are no points of reference for the position determination. Therefore, there is no unique solution for the localization from the run-time measurements (Fig. 5).

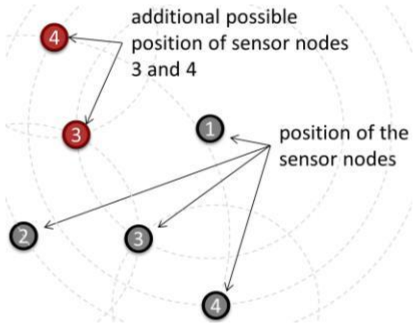

Fig. 5. Position of four sensor nodes (grey) and additional the possible position of the sensor nodes 3 and 4 (red).

Additional information is required. To give a rough estimate of where the nodes are, each sensor node has a compass, four ultrasonic receivers and four ultrasonic transmitters. This gives the possibility to transmit in different directions. Thus, from the direction of a signal can be roughly estimated. With this additional information, a relative localization of sensor nodes can be performed.

V.CONCLUSION

We presented an energy-efficient, low-cost wireless sensor node Sniff Node. This system is for spatially resolved, accurate gas measurements in the case of a disaster. The costs of a system are less than 100 euros and the system is designed to operate several days without changing batteries. The sensor node is a part of overall complete system for the investigation of a disaster area.

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